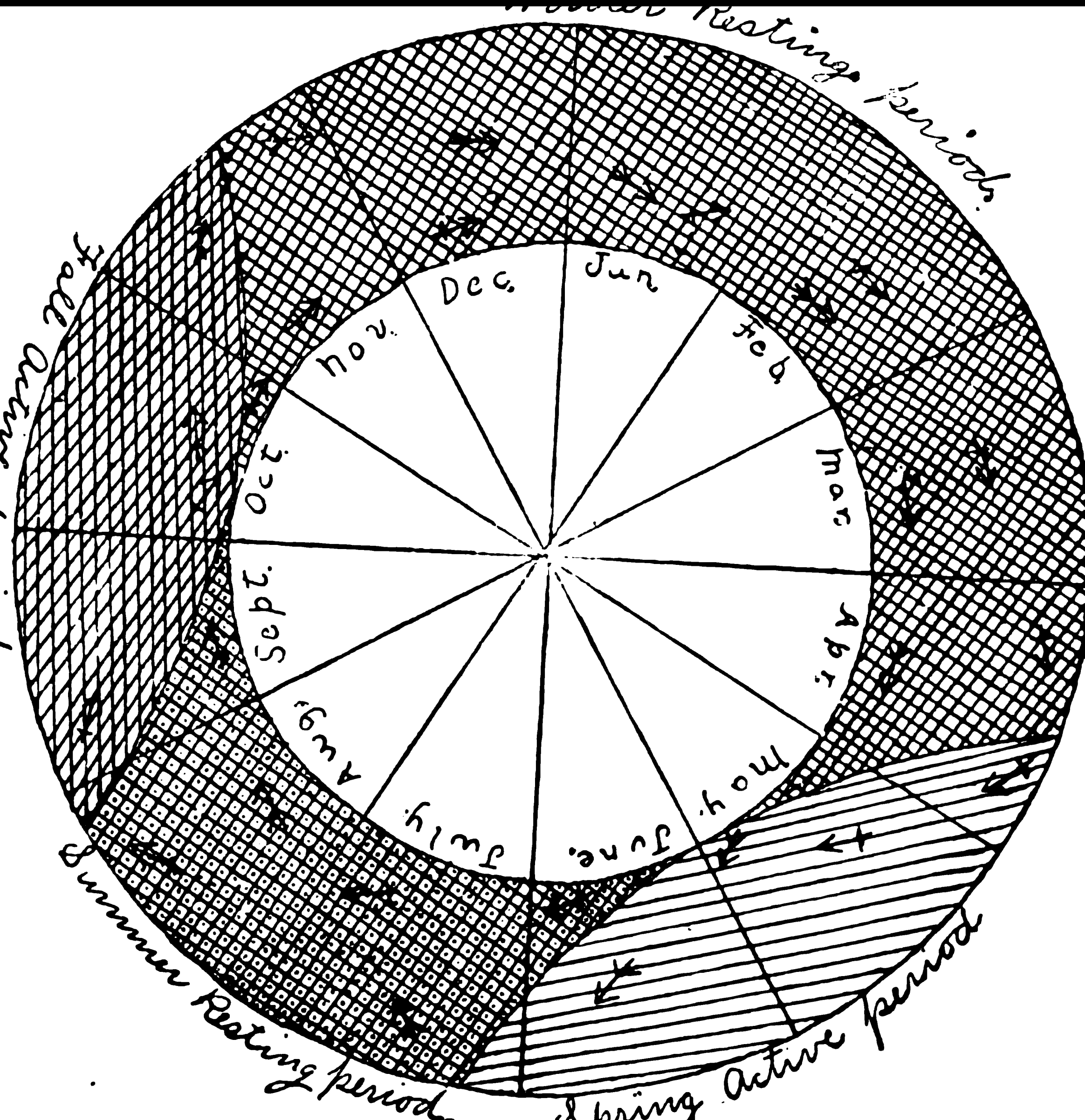
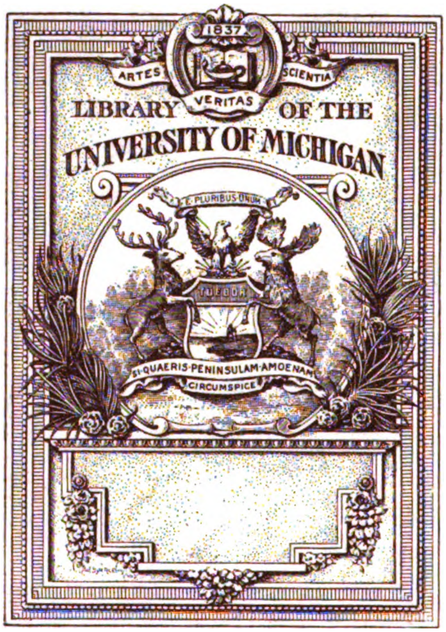


Bulletin

Ohio Agricultural Experiment Station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Ohio Agricultural Experiment Station.

BULLETIN 106.

WOOSTER, OHIO, APRIL 1899.

THE CHINCH BUG.

EXPERIMENTS WITH INSECTICIDES.

The Bulletins of this Station are sent free to all residents of the State who request them.
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OHIO AGRICULTURAL EXPERIMENT STATION.

BOARD OF CONTROL.

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BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 106. APRIL, 1899.

I. THE CHINCH BUG. II. EXPERIMENTS WITH INSECTICIDES.

BY F. M. WEBSTER.

I. THE CHINCH BUG.

In both bulletins 69 and 77, I called attention to the fact that there are in Ohio two forms of chinch bug. In one form the wings are always of the ordinary length, fitting the possessor for flying, (Fig. 1), and in

FIG. 1.

the other, in many cases and sometimes in the majority, the wings are so abbreviated as to render them useless as a means of locomotion. In these last the wings are not all of equal length, but vary in different individuals from almost a total absence to nearly or quite full winged, as is illustrated in Figs. 2, 3, 4, 5. All of these figures are enlarged and the natural length is indicated by the line under Fig. 1. This form, including large numbers of the short-winged individuals, seems to occupy only

other. Some studies made in Ohio at a later date have been included in Bulletin No. 51, published in 1893, but the supply of both of these bulletins has been exhausted and there is nothing now available, relative to this pest, that can be distributed to such farmers as desire published information with regard to the insect. For this reason I have revised the information contained in these two bulletins, and brought the subject up to date, the present bulletin being, therefore, really a revised second edition of the earlier of the two publications above mentioned.

BRIEF DESCRIPTION OF DIFFERENT STAGES OF THE HESSIAN FLY.

This is a small, dark colored, two winged fly, about one-eighth of an inch long and shaped much like the Wheat Midge, both belonging to the same order and family of insects. The male, Fig. 1, is more slender than

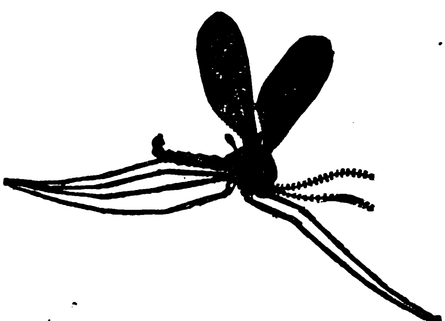

FIG. 1.

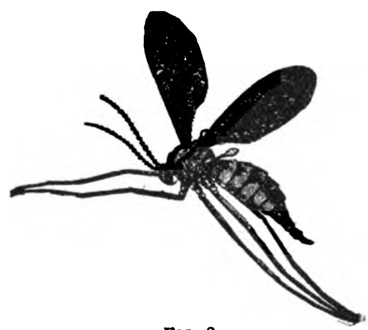

FIG. 2.

the female, Fig. 2, which, when full of eggs, slightly resembles a diminutive mosquito moderately full of blood. The life of the insect in the adult stage is short, the male dying soon after pairing and the female soon after oviposition. The egg, Fig. 3*a*, is about one-fiftieth of an inch long, of a dull reddish color. The larva or maggot, Fig. 4*b*, is, when first hatched, of a nearly white color, with a tinge of red, but later they are very light green, clouded with white. The pupa, Fig. 4*d*, is formed un-

FIG 3.

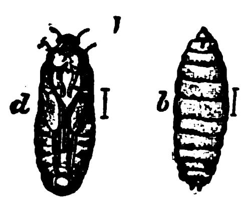

FIG. 4.

der cover of the puparium, Fig. 3*c*, which last is known as the "flaxseed" stage, on account of its resemblance to a flaxseed in form and color. This term is frequently used throughout this bulletin for the reason that the insect is best known under this name, in this stage of development.

EARLY HISTORY.

Although the destructive character of this species had been well known for many years, the adult insect was not described until 1817. The popular term by which it is now universally known appears to have originated, either directly or indirectly, with Col. George Morgan, of Prospect, New Jersey,[1] under the impression that they had been introduced into the country by the Hessian troops on Staten and Long Islands, in August, 1776. In a letter addressed to Sir John Temple, then Consul General for his Britannic Majesty in the United States, dated August 26, 1788, Mr. Morgan said:

> "I have satisfied myself that the Hessian fly was introduced into America by means of straw, made use of in packages or otherwise, landed on Long Island at an early period of the war. Its first appearance was in the neighborhoods of Sir William Howe's debarkation, and at Flatbush[2]."

The correctness of this theory of introduction has always been a matter of contest; but, be it true or not, the first really authentic account we have of the ravages of the pest, in America, was in the immediate vicinity of the locality where the landing of these troops occurred, and in the year 1779 — three years after the event took place. Reports there are of the ravages of insects, said by the unscientific to be identical with the Hessian fly, many years earlier, but these lack authenticity, and when we take into consideration that over a century later at least four-fifths of the reports of the appearances and depredations of the fly are to be accepted only after investigation, we may well exercise caution in accepting similar, early and vague reports. If, however, the pest was introduced at the time and place mentioned, it must have been brought over in great numbers. A little over two years is a short time for even this pest to become seriously destructive over even a limited area, and at least as early as 1780 or 1781 we find farmers in that vicinity adopting a yellow-bearded, Southern variety of wheat, which seemed to be less affected by the attacks of the fly. Its continued advance may be recorded as follows: Pennsylvania, 1786; New Jersey, 1786; Virginia, 1801;* Lower Canada, 1805 to 1816; Maine, 1823; Michigan, 1837; Wisconsin, Indiana and Illinois, 1844; Georgia, 1845 and 1846; Iowa and Minnesota, 1860; South Carolina and

[1] Pennsylvania Mercury, June 8; September 14, 1787.

[2] American Farmer, vol. 7, p. 153.

*This is according to the chronological table given in the Third Report of the U. S. Entomological Commission, pp. 232-3. In the Proceedings of the Agricultural Society of Albemarle (Va.), as published in *The American Farmer*, vol. 1, pp. 300-1, Mr. James Barbour, of Barboursville, Orange Co., Va., states pointedly that the Hessian fly first appeared in that section and "materially affected the crops" in 1798, and he very evidently was familiar with the insect of which he wrote.

Kansas, 1871, and California in 1885.[a] I fail to find any definite record of the earliest appearances of the insect in Ohio. Dr. Chapman states that it ocurred "west of the Allegheny mountains" in 1797, but does not say whether in Ohio or elsewhere. In the Report of the Commissioner of Patents, for the year 1848, p. 535, Mr. James D. Summers, of Troy township, Richland county, makes the statement that be began to apply lime to seed wheat as a remedy for the fly, in the fall of 1840. Its occurrence in 1797, in this State, seems doubtful, but it certainly must have reached here before 1840, the date usually given for its first appearance. In fact, a letter received recently from an aged and very intelligent gentleman, Mr. Luke Smith Motte, of West Milton, Miami county, Ohio, indicates a much earlier occurrence than has been previously recorded. Mr. Motte says:

"My memory runs back very clearly to 1815, and I well remember the plentiful harvest of 1820, when we used the hand sickle, and the reapers put on their overcoats to go out into the fields. The Hessian fly was here long before 1840. The first we remember that farmers' attention was called to this 'fly in the wheat' was in 1824–5, or maybe a year previous. It seemed to spread rapidly, so that farmers became watchful and cautious in regard to time of sowing."

NUMBER AND DEVELOPMENT OF BROODS.

Dr. A. S. Packard states that as a general rule there are two broods of the fly, the first laying their eggs late in April and in May, the second brood of flies ovipositing in August, during September, and a few early in October. On the same page Dr. Packard, under the head: "A third brood may sometimes appear," cites the finding of empty "flaxseeds" in volunteer wheat in Michigan in September, and in a foot-note is the statement that Mr. F. S. Sleeper saw flies ovipositing as late as October 26, and also, in 1878, as early as in February. Mr. Herrick noted the occurrence of flies in October, but supposed them to have evolved from pupæ of the preceding June. Mr. Hulick supposed adults found in Michigan during October to have emerged from pupæ in volunteer wheat. Mr. Caleb S. Fuller, however, reared adults also in Michigan from wheat sown on August 31, and Mr. Tilghman speaks of the appearance of flies in October in Queen Anne's county, Maryland, in a manner that would indicate that it was of ordinary occurrence.

In ordinary seasons, and throughout the area north of Lat. 37° N. and south of Lat. 45°, or thereabout, and between the Rocky and Allegheny mountains, the statement made long ago by Dr. Isaac Chapman that the Hessian fly is double brooded is true. While in the southern portion of Ohio the fall brood of adults appears some weeks later than in the northern part, nevertheless I have found but two destructive

[a] Am. Nat., Vol. XIX, p. 716, 1885.

broods. Between these two broods, however, is a considerable mass of fluctuating individuals, the true position of which is rather uncertain.[4]

There has always been a diversity of opinion as to the number of annual broods of the Hessian fly, even among entomologists, who have decided the question, each upon the data furnished by the area over which he has himself studied the insect, while as a matter of fact, if all of the work accomplished is brought together and studied in connection with the somewhat variable habits of the insect, as affected by geographical distribution, we shall find, not that the work of the entomologist has not been well done, but that what is true in one locality may not necessarily hold good in all others, and that a view of the whole area of distribution is likely to show that all have been right, except in their general conclusions. I believe it is due to this that entomologists have claimed anywhere from two to six annual broods of the Hessian fly, while it seems to me doubtful if there are as many as six in the far south, while on the northern border of its habitat there may be but one.

The idea of these additional broods is a very old one, and dates back to 1820, Mr. James Worth having that year observed the adult April 19; eggs, April 24; pupæ, May 15; adults early in June, and on the 12th of same month all stages were observed. Adults were noticed from the 15th of the following August until October, and again November 25, and he reared them indoors, December 25 and February 20. In summing up the matter he says: "It may then be said, that during the past year, (1820) there have been three complete broods and partially a fourth." [*American Farmer, Vol. III, p.* 188, *also loc. cit., p.* 213.

As Dr. Lindemann, of Moscow, Russia, in his "Die Hessenfliege in Russland," has well stated, the puparia are greatly influenced by environment, temperature, etc., and this is probably true of the other stages, larvæ of different ages being, for all we know, influenced to a different degree. To these facts must be added another of considerable moment, viz., while nominally two brooded, "flaxseeds" collected by me in the spring of one year have lived over to the spring of the following year. This is also true of at least one of the parasites of the species. How far the number of these interlopers is augmented by a retarded development of greater or less extent it is impossible to say, but that there is an accession through this means there can be no doubt. In fact, it would appear as though nature had in this way provided against the extinction of the species.

It would seem that we had here the two perplexing features of the problem of the number of annual broods, viz., variation in time of appear-

[4] Dr. Fitch states that the eggs of the fall brood are deposited in the State of New York early in September, and also that "the deposit is doubtless made later to the south of us than it is here in New York." (Seventh Report.) Mr. Edward Tilghman observed oviposition in Queen Anne's County, Maryland, about latitude 39° to 39° 30′, during the second week in October, and mentions it as of usual occurrence. (The Cultivator, May, 1841.)

ance of the brood, due to latitude; retardation of individuals due to any one of several influences; and, possibly, acceleration in the case of others. As applicable to the country lying between the Allegheny Mountains and the Mississippi River, and between the Ohio River and the Great Lakes, I have attempted to illustrate in Fig. 5, ideographically, the annual cycle of this insect, which can of course be only approximately correct for any single locality, there being a variation of nearly if not quite one month in the season of development between northern and southern Ohio. It will be observed that there are four seasons in this cycle, two of activity and two of inactivity, or, we might term the latter resting seasons. Over this area the winter resting season is by far the longer, while the two active seasons are about equal. Toward the south I believe the winter season will be found to be shorter and the summer season lengthened until they become equal, while to the north I confidently look for the autumn season of activity to wholly disappear and the species found to be single brooded.

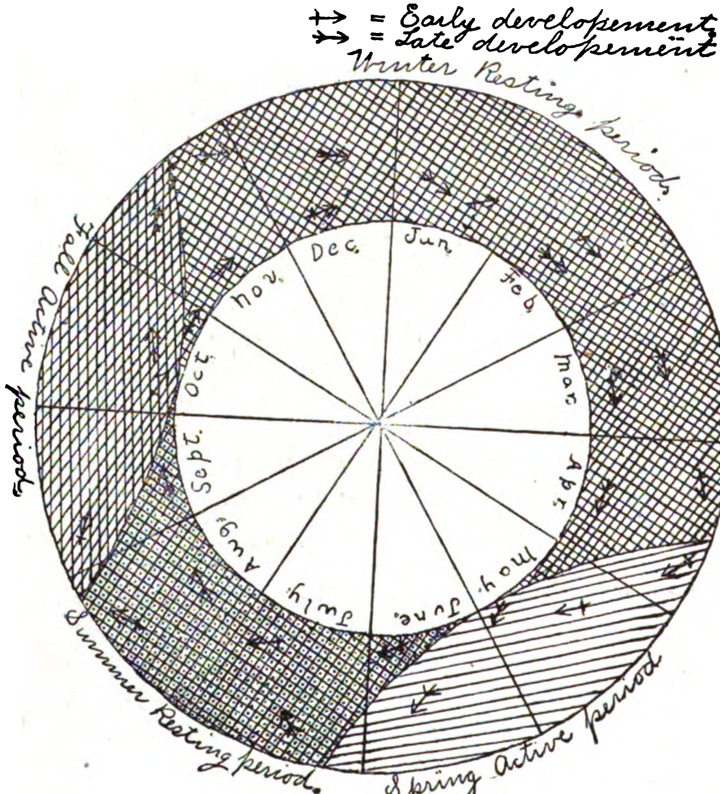

Fig. 5. Illustrating the annual cycle of the Hessian fly.

It will be noticed that the arrows alternate from the outer to the inner edges of the circle thus: The arrow indicating the late development of larvæ in November, crosses to the inner edge at May, indicating that the adults from these will appear late the following spring; while larvæ entering flaxseed stage in October develop adults early the following spring — the arrows in this case crossing from the inner to the outer edge of the circle.

Heretofore we have told people that the fly could not exist except where fall wheat was grown. But this can be said no longer, as the pest occurs in North Dakota and in a locality where fall wheat is never sown. Since the fall brood of flies emerges continually earlier as we go northward, it seems to me that we must eventually reach a point where it will cease to appear in autumn at all, and will go over until spring, a state of affairs that will easily account for the breeding in spring wheat in North Dakota. In other words, I expect to find that nature has protected the species alike from the protracted northern winter, and the equally prolonged southern summer, by varying its resting season with the latitude, and, possibly, also with its proximity to the sea coast. That is, we shall find the insect passing both the hot and cold seasons largely in the flaxseed stage, that being the stage of development during which it is best protected from the elements and lack of food.

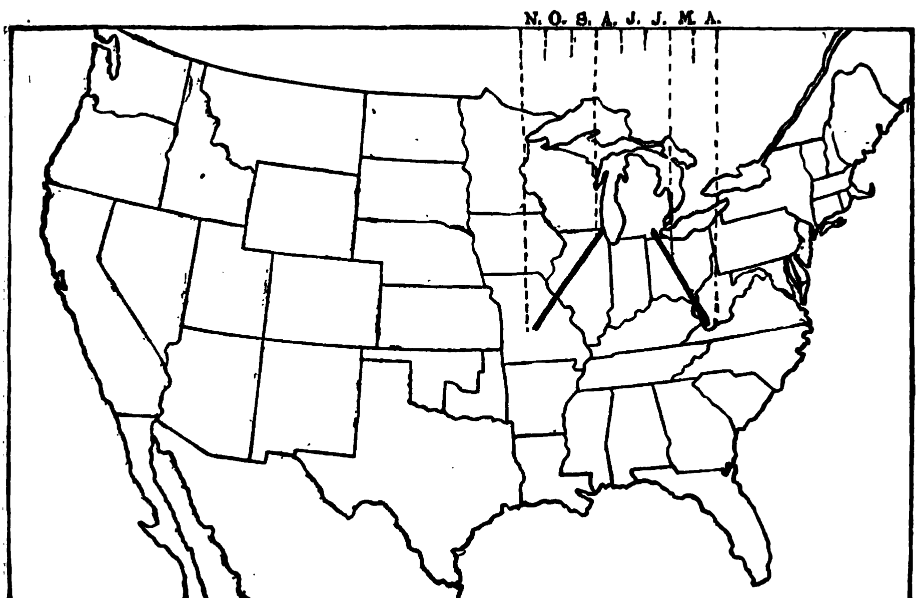

Fig. 6. Illustrating the divergence of the two annual broods of the Hessian fly with reference to date and latitude; the letters at upper margin, N, O, S, J, J, M, A, indicate the months from April to November while the heavy, oblique lines represent the diverging of the two broods to the southward and their approach to each other northward.

There are several good reasons why we might expect the fall brood to become extinct to the north, while the spring brood continues, the principal one being that there is not sufficient time for the former to develop before the cold season begins. Besides, in the continuity of the species it can best be spared, and I understand it is not present in England. In nearly all cases where a species is two-brooded, the spring-appearing brood of adults is the producing, while the fall is the diffusing brood. The spring-appearing flies are loth to leave the field in which they originated, and prefer to oviposit on the tillers of the wheat plant, while the autumn-appearing adults will spread out everywhere over the country, and will seemingly, scent out a field of wheat at long distances. They can even be drawn to very small plots in the midst of large cities.

It would seem, then, that the continuity of breeding having been interfered with by the winter months, we might naturally expect some of the adults that should appear in the spring, to emerge in the fall in sufficient time for their offspring to become far enough advanced to enable them to withstand the winter, yet lacking so much of full development that a considerable period of time in spring would be required to enable them to become fully developed. It would not be at all surprising if we found these stragglers appearing simultaneously with the advanced individuals, if such there be, of the next fall brood. I think that we can accredit the apparent additional broods to this overlapping. I have tried to make this clear in Figure 6. Now in regard to the time of the appearance of the real brood, the observations of thirteen years in Indiana and Ohio have shown that, in the spring, the Hessian fly develops later as we go northward, simultaneously with the advance of the season, which is estimated to be, approximately, 12 miles per day; so that the spring brood of flies which might occur in Virginia and southern Kentucky, in April, would probably not put in appearance in Ontario, Canada, Michigan and Wisconsin until June. The same extended studies over precisely the same area has shown that in the fall brood this condition is reversed, and that the adults emerge earlier in the north and later as we go southward in about the same proportion. In Figure 6 I have assumed that Hessian flies were abroad in Virginia and southern Kentucky during the latter part of April. I have assumed this to occur because, though I have not studied them there, I have studied them in southern Indiana, where this state of affairs does exist. Throughout Indiana and Ohio I have traced the development of these broods northward to the Michigan line, and shown that there is a much shorter period between the spring and fall brood in northern Ohio and Indiana than there is in the southern portion. In the fall this amounts to nearly or quite an entire month, as is indicated in Figure 7.

Fig. 7. Map showing areas over which the adult Hessian flies, of the fall brood, have developed and disappeared by the dates indicated between the lines.

Referring to Figure 6, then, it will be seen that at a point somewhere near central Michigan, Ontario, Canada, Wisconsin and southern Minnesota, two heavy oblique lines would come in contact with each other. By this I have indicated that with a continual late appearance of the fall brood and a continual early appearance of the spring brood there would come a point where it would be impossible for the insects of the first brood to reach the adult stage in time for the progeny of these to become sufficiently advanced to stand the winter and they would therefore go over until the following spring in a stage where they could pass the colder months safely but the effect of this would be that the fall brood of larvæ would drop out and the species become single brooded. As near as I can determine without actual studies and investigations, this point

would be somewhere in the vicinity of latitude 45° north, and in that latitude I should certainly expect to find the Hessian fly single brooded, instead of double brooded, which would easily admit of its attacking spring wheat, as, with the exception of one observation by Dr. Fletcher, we have no record of its developing on any of the grasses in North America.

As to the number of broods south of extreme southern Indiana and Illinois, I have never been able to study the species in that latitude, but it seems to me that it would not be possible for more than a certain number of broods to develop upon the grain plant, of which there is but one crop grown annually. Still it is not impossible that an additional generation may develop in volunteer plants, although it would hardly seem that this could follow to any marked degree. What is really needed is a careful study of the Hessian fly from the latitude of extreme southern Illinois southward to the Gulf; and I do not believe that it is possible to give an accurate knowledge of the life history of the insect until this has been done. As I have indicated, the situation in England does not differ materially from what I have stated as true in the northern portion of this country, as there does not seem to be more than one annual brood there. Whether the same may be said of Russia or not, I would not care to say, as Dr. Lindemann appears to have made a most careful study of the species in his country; but I have always thought he may have fallen into precisely the same error that we have in this country.

EXPERIMENTS AND OBSERVATIONS MADE IN INDIANA.

My own experiments, notes, and observations upon this insect in Indiana extend over a period of a little over six years, and while during that time the Hessian fly received little more attention than was given several other wheat-destroying species, a considerable number of facts accumulated which, while not by any means clearing up all of the mysteries of the pest, nevertheless serve to throw some light on several obscure points. Unless otherwise stated, all of my observations and experiments herein recorded were carried on in the adjoining state of Indiana, extending from latitude 37° 50′ to about 41° 45′ N.; and with the exception of meteorological conditions as indicated by what are known as Isothermal lines, the results will, I still think after seven years additional study, apply equally as well in Ohio as in Indiana.

These experiments and observations were conducted almost exclusively out of doors and very largely in the fields, as I consider indoor and breeding-cage observations on this species, except for the purpose of securing specimens and parasites, of very doubtful value from an economic standpoint or as indicating its normal habits. The observations have many of them been once and often twice substantiated.

At LaFayette, Ind., latitude 40° 27′, (Columbus, Ohio, is latitude 40° N.) wheat plants were transferred from the fields to breeding cages April 5, 1890, and kept out of doors. The seed producing these plants had been sown September 3. On April 17 a female emerged, and a male appearing soon after, these, on April 22, were both placed together on young growing wheat, planted in a breeding cage out of doors. From these, adults were secured June 8. The attempt was made to follow the offspring of these, but failed on account of the wheat being killed by rust. On June 7, and also on the 14th, 1888, in the same locality, adults were observed ovipositing, the eggs being placed on the youngest and most tender shoots, and there was every evidence that these eggs developed through the larval to the "flaxseed" stage by early July. Besides, I have observed in the same locality late-growing shoots literally overrun with very young larvæ on the 26th of June, and found larvæ as late as the 10th of July.[5]

On October 16, 1887, Mr. W. S. Ratliff, who made a great number of experiments for me, near Richmond, Ind., (latitude 39° 51′, and about the same as Springfield, Ohio,) secured adults from a small plot of wheat plants which appeared above the ground September 4. From a plant from this same plat that had been transplanted in doors, he secured an adult female 11 days earlier. In either of these cases, with favorable weather, the female could have sent her offspring into the winter in the "flaxseed" state. Mr. Ratliff also observed adults on July 10, 1887. At LaFayette, Ind., the same autumn, I saw females ovipositing on November 3, in a temperature of 64° F., among the plants. From a plat sown August 13, and which came up on the 17th, I obtained adults of both sexes on October 1, 44 days after the plants appeared and 48 days after sowing. That larvæ, even though quite immature when winter begins, may survive till spring, has been demonstrated again and again, and was especially true of the exceedingly mild winter of 1889-'90. In fact, by a series of sowings all stages of the insect can be produced in small numbers continually from April to October, and by keeping a cage indoors I have produced adults in abundance in January.

It is true that observations during a single season, in a single locality, might produce apparently good evidence of a third brood, but a continued close study of the species in such locality will probably show it unfounded. That these aberrant individuals may, under favorable conditons, collect or "bunch" together in certain fields is probably true, but my own experience has been that the following year this irregularity will have disappeared or have been reduced to a minimum by the effect of the weather during midsummer and winter. On June 24, 1887, near Princeton, Indiana, latitude 38° 23′ N., I found a field of wheat, sown

[5] Flies began to appear on the farm of Mr. Jonathan N. Havens, Shelter, Island tp., Suffolk County, Long Island, on the 16th of April, 1787. (American Farmer, Vol. VII, p. 153.)

about the first of the preceding November, literally alive with larvæ from one-fourth to nearly or quite full grown. There were no pupæ to speak of in this field at the time, but in other fields in the vicinity these were abundant, but here there were no larvæ to be found. At this date wheat harvest was at its height. The late-sown field had evidently attracted the late-appearing adults of the fall before, and their progeny, living over in this field, as delayed larvæ, emerged correspondingly late in the spring, giving rise to the generation of larvæ observed by me. My reason for taking this view is that I have several times tried to draw off the spring brood of flies by offering them young plants on which to oviposit, but have always failed, as they seemed to prefer tender shoots of older plants to the young plants themselves. In the fall this characteristic seems to be somewhat the reverse, although even then, if attacked after tillering, the tillers will be chosen instead of the main stem. The fall brood of adults is probably the migratory brood, and their power of detecting wheat plants is almost phenomenal.

I have drawn them to a small plat of wheat sown in a secluded corner of my garden, in the midst of town, fully half a mile from any wheat fields. But, be this as it may, a second brood of larvæ in June would be rather difficult to sustain, as the puparia of the earlier part of the month are known to remain in that stage until September. Neither have I been able to secure any better evidence of a brood originating in volunteer wheat during July and August. Puparia are to be found every year from one end of the state to the other in this volunteer wheat, but in Indiana I have never found these sufficiently numerous to imply a distinct brood. Professor Forbes and his assistants, working in Illinois, appear to have a greater confidence in this extra brood than myself, although, as will appear further on, our experiments were carried on the one perfectly independent of the other, though only a few miles apart.

My attention had been called to the condition of this field near Princeton, by Hon. Samuel Hargrove, a member of the State Board of Agriculture, who willingly agreed to further aid in the investigations by sowing for me plats of wheat at intervals of about two weeks, beginning as soon as possible after harvest. Being detained in Lousiana myself until nearly the 1st of August and the weather being exceedingly dry, no plats were sown until August 4, 1887, followed by another on August 22, and a third September 5. These were sown on one of Mr. Hargrove's farms, about 10 miles northeast of Princeton, about the latitude of Lawrence county, Ohio.

The first two sowings, owing to the drouth, came up sparingly and about the same time. The third was also affected by drouth, and did not come up until about the 1st of October. These plats were sown along the lower edge of a high, rolling stubble field, which had been too dry to plow, and in which I had found an abundance of "flaxseeds" the preceding June.

These plats were examined by me on October 8. The two earlier-sown had thrown up a good growth of plants, which had tillered finely, being along a low ravine. On these plats I found a number of larvæ, which were nearly or quite grown, and a less number of "flaxseeds," one of which was empty. Besides these, the plants were literally alive with very young larvæ, so young in fact, that they had not yet lost their reddish tint. The third plat had sent up the normal number of plants, which were now in the second leaf. These plants had not appeared in time for the earlier deposited eggs, but were even more seriously infested by young larvæ, than the plants of the two earlier plats. One of the plants from the last plat contained twenty-six young larvæ, all of which must have hatched from the eggs only a few days prior to my observations. Now, from whence did the progenitors of these young larvæ originate? Most assuredly not from volunteer wheat, because there was none. Not from my earlier-sown plats, else these would have shown the effect. There are, it seems to me, but two other sources from which they could have come, viz., the stubble, which I know to have been infested, and grasses, which we have no knowledge of the species affecting this side of the Rocky mountains.

These plats were plowed up soon after examination, as I was afraid to allow them to stand thus, a menace to the adjoining fields the following spring, though the plants would have probably been destroyed before even a small portion of the larvæ matured.

From all the information that I am able to gather, the usual time of appearance of the fall brood of adult flies in southern Indiana is the last portion of September, and first days of October. This is, I believe, the opinion of the most observing farmers, including the late Hon. J. Q. A. Seig, of Corydon, Harrison county, who was also a member of the State Board of Agriculture and as familiar with the earlier stages of the pest and its effect upon fall wheat as I am myself. Mr. J. P. Louden, of Sharp's Mills, same county, stated that wheat sown on October 1, 1886, was damaged 50 per cent., while that sown on the 6th was injured only 15 per cent. Mr. J. A. Burton, writing from Mitchell, Lawrence county, November 24, 1887, gave the results of his examination of wheat fields as follows: Fields sown September 8, about one plant in 8 infested; sown September 15, about one plant in 12; sown September 22, about one plant in 50, and sown October 1, seemingly free from injury. The observations of these gentlemen also coincide with my own, made in November, 1888, in Harrison and Posey counties. Therefore, from all the information which I have been able to gain, the best season for wheat sowing, to avoid the attacks of the Hessian fly in extreme southern Indiana, is soon after the 1st of October. Exactly how far northward this advice will apply I am unable to say, but am inclined to think it would cover territory lying between latitude 38° and 39°, and possibly 39° 30′, although near the northern limit

it would probably be safe during ordinary years to sow soon after September 25.

During the years 1887 and 1888 Mr. W. S. Ratliff made a large number of very careful observations, and sowed a series of plats of wheat on different dates near Richmond, Ind. In 1887 plats were sown August 5 and 29, September 12 and 26. All of these plats were attacked and more or less injured except the last, which as late as December 19 showed not the least injury by the Hessian fly. Up to May 31, 1888, there was very little injury to this plat, and even on the above date there were very few larvæ as compared with the number on the others. From this date on till July 11 the plats were all injured by black and red rusts, chinch bugs, and the wheat stem maggot, the greater injury appearing to fall upon this, so that at harvest, July 11, the last was the poorest of all in yield, that sown August 15 being the best. The sowings of 1888 were as follows: September 6, 20; October 4, 22; November 1. On November 14 the first plat was found to be infested by larvæ of the Hessian fly. During June, 1889, chinch bugs again attacked the plants growing on these plats, and the grain aphis seriously injured the later sown plats, so that at harvest July 5, these latter were the poorest of all, the other three averaging about alike. All of these plats during both years had been sown in narrow strips among corn along one side, the remainder of the field being corn, and later also sown to wheat, thus bringing the latest-sown plats between those sown earliest and the entire field itself, as appeared to me, making the severest test to which I could subject the several plats. The results, while not conclusive or even entirely satisfactory, indicate that in that latitude about September 25 is, generally speaking, a good time to sow wheat to escape fall attacks of the fly and winter killing. A series of plats sown for me by Mr. Miles Martin, of Marshall, Parke county, Ind., is very near the same latitude as Richmond, but nearer the western border of the State, gave rather more conclusive results, the sowings of September 22 being almost entirely exempt from the attack of the Hessian fly, while earlier plats were infested.

In regard to my own observations at the Experiment Station at Lafayette, Indiana, I may state that I was never able to provoke a disastrous attack of the pest, though there was nothing left undone which could possibly induce the adult flies to oviposit at any time between March and December; and there is probably not a month between these dates during which the insect could not have been found in all of its stages. The two destructive broods, however, invariably appeared in the fields in May and September; in the latter case usually before the 20th.

My own experimental sowings were rather more elaborate and extensive than those of any of my correspondents, comprising a number of varieties and extending over several months. Without going into details, the experiments and results may be summarized as follows: 1887, plats comprising the varieties Michigan Amber, Clawson and Velvet

Chaff, each, one width of a grain drill and twenty rods in length, were sown on the following dates: August 13, 27; September 10, 24; October 8, 27; November 5, 19. The autumn was very dry, and the plants of the first six plats went into winter in poor condition, being very small, while the last two sowings did not come up until the following spring. The severe winter destroyed the plants so generally, that only the first three produced sufficient grain to pay for harvesting. These were also the only ones to suffer from the fall attack of the fly, the first producing adults October 1. Plat 8, was attacked on the following June, and on the 26th was badly infested with young larvæ, full grown larvæ and puparia, the latter, the most numerous, were found on the 16th of July. The plats harvested produced a poor crop, but the Michigan Amber ranked first, Velvet Chaff second, and Clawson the poorest of all.

The condition of the Hessian fly in these three plats, at the time of harvest, July 10, 1888, may be inferred from the result of examinations made on this date:

Empty "flaxseeds"	15
Containing healthy pupæ or parasites	69
Larvæ	16
Total	100

August 3, the state of the insect in these same plats was as follows:

Empty "flaxseeds"	53
Containing healthy pupæ and parasites	47
Total	100

The condition of the insect on September 1, as shown by examination of the stubble, is indicated below:

Empty "flaxseeds"	55
Healthy "flaxseeds"	28
Parasitized "flaxseeds"	17
Total	100

Notwithstanding the per cent. of healthy puparia passing the summer was small, there is little probability that many adult flies emerged. A plat of the same dimensions was sown July 16, along one side of the first three sown the previous fall, the plants of this last sowing coming up ten days later. This plat was closely watched. After July 17 only an occasional larva was found on volunteer wheat and none of course on the latest sown plat. By August 4, plants had been destroyed by the combined influences of chinch bugs and dry weather, but a second plat had been sown adjoining, and the plants of this appeared above ground on August 6. On September 4, 200 plants were examined and but two larvæ

plats of 1888 were not properly sown, Mr. Banks not being able to attend to them himself; but a visit to the locality on November 8 revealed but very little injury to wheat which had been sown after the middle of September.

The experiment plats of 1890 were sown September 1, 10, 20, 30. These were examined late in October and fully substantiated the experiments of previous years. The sowing of September 1 was considerably injured, while that of the 10th was very seriously affected, as was also a large field adjoining sown but a day or two later. The sowing of September 20 was comparatively free from attack, while that sown September 30 appeared to have almost entirely escaped injury.

The sixth and last series of experiments were made for me by Hon. J. N. Latta, at Haw Patch, Lagrange county, in about the same latitude as La Porte. The sowings were made in 1887, the first being drilled on July 28, but owing to drouth the plants did not appear above ground until about the 28th of August. The second plat was sown on August 15, but came up the same time as the first; the third, sown Septmeber 1, came up September 6; the fourth, sown September 12, came up September 21; the fifth, sown September 24, came up the 28th; while the sixth and last was sown October 12, and did not come up until about the 20th. These plats were examined by me on October 17; the first three and the last sown were very poor, the fourth and fifth promising a fair yield. A field adjoining, sown on the same day as plat 5, did not suffer from the fly and produced nearly an average yield of 20 bushels per acre. The results of these meager experiments have, as a rule, proven correct in the fields of the farmers. I have not only observed this myself, but it has become well known in the locality that wheat sown before September 15 and after the 30th of the same month seldom produces a good crop, while that sown between the 15th and the 25th is the most likely to escape the attack of the Hessian fly, and, as a general thing, winters as well as that sown earlier, provided the sowing has been done properly.

STUDIES AND OBSERVATIONS IN OHIO.

No systematic field experiments among farmers have been carried out in Ohio, as was done in Indiana, but examinations have been made in wheat fields throughout the State, whenever opportunity was offered to do so, and these have extended from the extreme northern to the extreme southern portions, and during nearly all seasons of the year.

Besides these field observations, the Experiment Station has carried out an almost continuous series of early and late sowings for the last eleven years, beginning in 1888, at Columbus, and with the exception of a single year, extending over a period of four years. At Wooster, the series was started in 1893, and with the exception of two years, extended continuously up to 1899. These sowings were carried on under the

direction of the Agriculturist of the Station, Mr. J. F. Hickman, and though the principal object of the experiment had no special reference to the Hessian fly, yet it will be seen that the sowings were an exact continuation of those that I had been carrying on in Indiana. Without going into details, then, it will be sufficient to state that at Columbus, Ohio, latitude 40°, it was found that the fall brood of the Hessian fly had largely appeared and disappeared by the 25th of September; and that fall wheat sown after that time, was almost wholly exempt from the attack of the larvæ. At Wooster, latitude 40° 49′, the experimental sowings have shown us, very clearly, that the fall brood of flies have disappeared by the 20th of September, and I believe, usually, by the 18th; although in some seasons wheat sown as late as the 14th of September has suffered quite severely from attack of the fall brood of larvæ. As compared with the similar latitudes in Indiana, it will be seen that these results are almost exactly parallel with those obtained in the latter State, and based as it is upon these data, secured in two states during the thirteen years that I have been making the Hessian fly a study, the map shown in Fig. 7, will give an approximate idea of the season during which the fall brood of flies are abroad throughout the State. It is not to be supposed that these dates apply exactly over the whole area between the heavy lines on the map; as, for instance, there would, as a matter of course, be a few days difference between northern Wood county and southern Seneca county; or between northern Wayne county and southern Carroll county; or between northern Logan county and southern Champaign county; but the dates given are as near as can be obtained without actual experimentation upon the farms located within these various areas. For the sake of convenience, these cross lines on the map in Fig. 7 are located upon the degrees and half degrees of latitude, as these will always furnish a basis from which it will be possible for the exact farmer to work. Of course there is always the uncertainty to be taken into consideration that with a rather high temperature and moist ground, wheat will germinate much more quickly than if the weather happens to be very dry; so that, in order to be safe the farmer will need to delay for perhaps two or three days later than the dates given throughout the southern border of the area within which he may reside, while the one located near the northern border will probably not have occasion to take this precaution.

OVIPOSITION.

The habits and transformations of the Hessian fly in America seem to have been first thoroughly studied by Dr. Isaac Chapman, who gave us substantially the life history, as it is now understood, in a paper published in 1797.[6] In 1841 there appeared three important contributions to the

[6] Memoirs of the Philadelphia Society for the Promotion of Agriculture, vol. V.

literature of the species, viz.: A Brief Account of the Hessian Fly and its Parasites, by Edward C. Herrick[7]; the second by T. W. Harris[8], and the third by Mr. Edward Tilghman[9], who had also written on the subject substantially the same 21 years before.

Mr. Herrick described the egg, and both he and Mr. Tilghman observed and recorded the method and place of oviposition, both stating that the eggs were placed on the upper sides of the leaves in the long creases or furrows thereon. Prof. Riley, however, records[10] the fact that this is not always the case, but that the spring brood of flies at least sometimes push their eggs under the sheath and between it and the straw. As to the number of eggs placed at one time, Mr. James Worth stated that he had counted 208 eggs on a single leaf.[11] Mr. Herrick says that the number varies from one to thirty. Prof. Riley says the eggs are placed in irregular rows, ordinarily of five or ten in each row. Prof. A. J. Cook, however, states that the female rarely deposits more than three eggs without changing her position, and generally but one.[12] He does not definitely state that no more are deposited on each leaf, but states that "in case she lays but one it takes less than a quarter of a minute and less than half a minute to lay three, when they are all laid without a change of position on the part of the fly. After laying she seems to draw in her ovipositor, soon to extend it again, at the same time crowding into it the one, two or three eggs that are next to be laid. She then flies to another leaf, alighting usually, not always, with her head toward the end of the leaf."

The eggs are deposited by the female very soon after she hatches from the "flaxseed," on the upper side of the leaf, as a rule, as indicated in Fig. 8. This task is finished in a few days, after which she dies. The

FIG. 8.

young hatching from the egg works its way downward, beneath the sheath to its base. In the fall this is just above the roots below the ground, as shown in Fig. 9, but in spring they do not go below ground, as a rule, but stop at or near one of the lower joints. The effect of the maggots on the young plants in the fall is fully illustrated in Fig. 9, an infested plant, and Fig. 10, showing one unaffected. The difference is further explained in the following pages.

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[7] Am. Journ. Sci., 1841, vol. XLI, pp. 153–58.
[8] Inj. Ins. Mass. Ed., 1841, pp. 421–37.
[9] The Cultivator, vol. 8, p. 82, 1841; Am. Farmer, vol. II, p. 235, 1820.
[10] N. Y. Tribune, Sept. 12, 1877; Third Rep. U. S. Ent. Comm., p. 211.
[11] American Farmer, vol. III, p. 188, Sept., 1821.
[12] The Hessian Fly, Lecture, p. 7.

EFFECT OF LARVÆ ON PLANTS IN THE FALL.

The effect of the larvæ, especially on the young plants, does not appear to be generally understood, and I have myself been able to verify either the figures or descriptions of Fitch and Packard, only in exceptional cases. The swollen bulb just above the roots in Fitch's figures gives but a vague idea of the true appearance, while Packard's figure represents plants which have very evidently sprung from seeds only slightly covered by the soil. Besides, the former figure only represents the condition of the plants long after the larvæ have done their work, and the latter, aside from one shoot being shorter, gives no idea of the appearance of an infested stem, as found in nature, growing in the fields. The yellow color of the foliage — there is usually more brown than yellow about it — appears later, after the larvæ are full-fed, and then it is largely, at least, confined to the younger leaves, the older ones, under whose sheaths the larvæ occur, are killed by the freezing weather of winter. I give a representation of an infested plant fresh from the field, drawn from nature, in Figure 9.

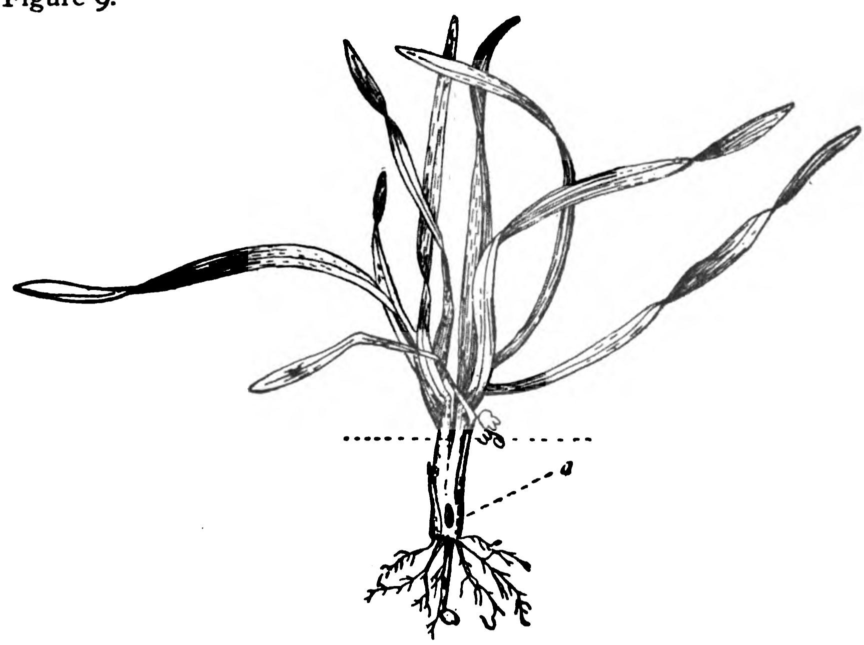


FIG. 9.

The plant had been attacked soon after its appearance above ground and had not tillered. The leaves under these conditions are broader, darker green, more vertical and bunchy. The youngest leaf on a healthy plant as it unfolds and pushes upward is of a tubular form and spindle-shaped, as represented in Fig. 10, showing a healthy plant. In the case of an affected plant, the stem having been destroyed below ground, the

spindle-shaped central leaf is always absent. The difference between a healthy and infested plant is shown by a comparison of figures.[13] If a plant has already tillered, each of the identical laterals, as they are attacked, will begin to take on the form and color above described. It is, therefore, not only possible to detect an infected plant without removing it from the ground, but also to determine the individual tiller infested. Now, while this feature of infested plants is so very clearly marked, at least after the larvæ are one-third grown, and from an economic standpoint of so much importance that it is surprising that it should have been overlooked, yet I can not myself lay claim to the fact by right of discovery, as it was pointed out to me by a farmer in the autumn of 1884.

Fig. 10.

If the soil is rich and the plants are attacked before they have tillered, these last will be thrown out from the roots which are not injured. These, if the fall be very favorable, and the winter does not commence too early, will often winter through and produce stem-bearing heads the following harvest. On the other hand, if the autumn be dry, or the

[13] When this matter was published, I supposed I was the first to record and figure this difference between healthy and affected plants. I now find that I was anticipated by about 65 years. *The American Farmer*, vol. II, p. 174, 1820, contains an illustration of both healthy and affected plants, in which this difference is clearly shown by the artist, and while there was no reference to this difference in the text, in the same publication, of August 15, 1823 (vol. V, p. 165), Mr. Thomas Beesley, writing from Cape May, says: "For the information of those that may not know how to find the fly in the fall, they will look for the spears that are the darkest green and stand most upright."

ground be frozen early in the season, the crop will probably prove a failure. This is the reason why some fields will present a much better appearance the following June, and give a much better yield than could have been anticipated from appearances during the fall. The practical value of knowing how to detect the infested plants readily is in that the destruction may be observed and the damage estimated long before the foliage turns brown or yellow, and the fields be plowed up and resown or allowed to remain, as the owner judges best. If resown, it would seem best to replow also. Mr. W. A. Oliphant, of Pike county, southern Indiana, writing me in the fall of 1884, in reply to a circular, stated that of 300 acres he had resown 200 acres after replowing, and 100 acres without plowing. The first yielded him 27½ and the last 11 bushels per acre.

EFFECTS OF LARVÆ ON PLANTS IN SPRING.

The popular notion in regard to the effect of larvæ on the straw is, so far as I know, usually correct. The year 1890, however, was an exception, at least so far as southern and central Indiana is concerned. As far north at least as LaFayette the larvæ of the spring brood were located just above the roots, and the straw did not break at the lower joint, as is usually the case, but either fell or was blown over from the roots, the culm usually being uinjured elsewhere. I observed this to a very limited extent at Oxford, Indiana, in 1881. In fields about La Porte, in the northern part of the State, none of this lower attack of the plant was noticed, the larvæ and later the puparia being invariably found just above some of the lower joints. Mr. James Fletcher, Dominion Entomologist of Canada, reported at the meeting of the Entomological Club of the American Association for the Advancement of Science at Indianapolis, that the wheat about Ottawa, Canada, had that year suffered from the attacks of larvæ of the spring brood in precisely the same manner as I had observed at LaFayette and southward. Quite a percentage of the pupæ in the fields about La Porte were located so high up the stem as to render it probable that they would be carried away with the straw. As yet I have not found a good reason for this difference, but have a vague idea that the killing down of the plants during the preceding March might have had something to do with it, as this was less severe in the northern part of the State.

THE EFFECT OF THE WEATHER ON THE DEVELOPMENT OF THE FALL BROOD.

It is quite probable that some autumns are more favorable for the development of the insect than others, but just what the favorable influences are is not well understood. Mr. Ratliff, at Richmond, Ind., saw an adult emerge from the pupa on October 16; the wheat which it infested appeared above ground on September 4. Between these two dates, Mr.

Ratliff's notes give the following record of minimum temperatures through which the insect must have necessarily passed:

	Min. Temp.
September 23 (frost)	26°
October 6 (light frost)	26°
October 11 (light frost)	34°
October 12 (light frost)	26°
October 14 (heavy frost)	24°
October 15 (frost)	26°
October 16 (light frost)	29°

Rains on September 11, 26, October 10. Total precipitation during September and October 2.50 inches.

At LaFayette, the same year, I found adults ovipositing on November 3, but of the origin of these flies of course nothing was known. The temperature through which these must have passed, supposing the eggs from which they evolved were deposited after September 1, was as follows:

	Min. Temp.
September 23	39°
September 24 (first frost)	29°
October 11	39°
October 12 (frost)	29°
October 14 (frost)	33°
October 15 (frost)	31°
October 16	38°
October 19 (frost)	31°
October 20 (light snow)	37°
October 21	29°
October 22	21°
October 25 (frost)	19°
October 26 (frost)	21°
October 27 (frost)	21°
October 28 (frost)	28°
October 29	33°
October 30 (frost)	19°
October 31	28°
November 1 (frost)	28°
November 2 (frost)	36°
November 3 (frost)	32°

Rains on September 7, 13, 14, 22, 27, 28, 29, 30, October 3, 9, 10, 12, 23. Total rainfall, 4.64 inches.

From this it will be observed that the adult flies may emerge and oviposit under what we supposed to be very adverse circumstances. To what extent the eggs and young larvæ are able to withstand such weather I have no facilities at present for demonstrating. The major portion of the fall brood of flies, however, emerge during a more favorable period, and for meteorological aid against these we can only look to the dry, hot weather of July and August, though to the south a portion of September

might be included. But the straggling individuals, which, as I have proved, may originate from stubble, volunteer, or even early sown grain, and which I myself can find no satisfactory reason for not considering either the retarded or accelerated individuals of either one or the other of both broods, have it in their power to reproduce a considerable progeny, which, though of themselves not a serious menace to the crop, yet, added to those of the remainder of the forthcoming brood, greatly increase the probabilities of serious damage. For these a long mild autumn, extending into December, would appear to be exceedingly favorable as it would enable their progeny to enter winter in a comparatively hardy state, and probably produce late appearing larvæ the following year, simultaneously with or but little in advance of the progeny of the earlier appearing adults of spring. In other words, the one winters as advanced puparia or unemerged adults, the other as advanced larvæ or newly formed puparia. It thus appears that while the autumn usually has little effect on the major portion of the fall brood, a mild October and November may emphasize the destructiveness of the pest. So far as observed by me, a damp spring, even though a cold one, is also favorable to the development of the insect, while dry, hot summers are as unfavorable, and cause serious mortality to the earlier stages of the fall brood of adults.

PREVENTIVE MEASURES.

These may be noticed as follows: Sowing at the proper time; burning the stubble; rotation of crops; sowing long, narrow plats in late summer as baits; applying quick-acting fertilizers to seriously infested fields in the fall in order to encourage attacked plants to throw up fresh tillers, and to increase the vigor of these that they may make sufficient growth to withstand the winter.

None of the measures are original with me, and in fact the most of them are as old as the history of the species itself. There is certainly much to be gained by the farmer in timing his sowing so as to avoid the larger part of the fall injury, and if all farmers of a neighborhood would sow about the same time even a serious outbreak would be so diffused as to lessen its injury.

Burning the stubble after harvest, recommended as long ago as 1792, when it is practical to do so, is usually recommended by the majority of writers. The plan is criticised by some authors on the plea that the parasites are also destroyed, which, if allowed to continue, would themselves overcome the fly. This idea has always appeared to me to be both theoretically and practically wrong. If only the normal number of wheat plants allowed by nature to spring up under a perfectly natural environment were produced, then the theory would be correct, because nature would then be working out her plans from the beginning. As the facts exist hundreds of thousands of plants are produced where nature intended

but one. Her domain is invaded and her law defied at the beginning. The Hessian fly is itself a parasite, the wheat plant being its host, and what we term its parasites are practically only secondaries. In the Hessia fiy, nature has an efficient servant in controlling the wheat plant, and the parasites of the former seem to be on guard to see that the duty is not overdone. Now we outrage nature and expect that she will uphold us by destroying these servants and permitting the indignity to go on. With this state of affairs the American farmer has found that the Hessian fly will be overcome by its parasites only temporarily, and then at the expense of a large per cent. of at least one crop. By burning the stubble we destroy all of the pest and also numerous other enemies which are to be found in the fields at the time. Some seasons, however, many of the flaxseeds were so situated that it is doubtful if enough heat would reach them to destroy all of them.

In a rotation of crop the adults are obliged to travel about in search of the fields, and there is a greater chance of their being destroyed while thus engaged. This, however, has its exceptions, as we observed at New Castle, about thirty miles northwest of Richmond, Ind., on November 17, 1888. The whole field had been sown in standing corn, a portion of it about the 5th of September and the remainder considerably later. The early sown portion had been seriously attacked and at least 85 per cent. destroyed; the later sown portion was only slightly injured, as was late sown wheat generally in the community. At the Indiana Experiment Station the plan of rotation is as follows: Corn one year, followed by oats one year, wheat one year, clover and grass two years. The wheat fields are then never seriously affected by the ravages of the Hessian fly.

Sowing narrow strips across the fields, early in the fall, as decoys, was long ago strongly advocated by Dr. Fitch, but the advice has been, so far as I have observed, totally ignored by the farmer. While it is hardly possible to thus entrap the major part of the fall brood of larvæ, it is certainly possible to entice to these plats the stragglers and interlopers, which we have shown to be capable of considerable injury. In this way the farmer can, in a measure, continue the influences of summer and winter in sharply separating and defining the two broods. In other words, while he can not eradicate the pest in this way, he can weaken its power to commit serious injury. It is very doubtful if the volunteer wheat-springing up after the wheat land has been plowed, can be used as decoys, and if allowed to stand until the date of sowing the fields, these volunteer plants should, by all means, be plowed under as deeply as practicable. Simply killing the plants will not do, as has been illustrated by the experience of Mr. Oliphant, previously cited, and by the observations of Professor Forbes, of Illinois.[14] If volunteer wheat is allowed to stand at all, it should not be over a fortnight. The proper time for sowing these decoys will probably vary with the latitude. For northern Ohio they should

[14] Bulletin 3, State Ent. Ill., p. 48, 1887.

be sown during the latter part of August, and in the southern part of the State not later than the first week in September. To the north and south of this State I have, as previously stated, no definite information as to the date of appearance of the fall brood of flies, and hence cannot undertake to settle the date of sowing. These decoys should not be permitted to stand over four weeks at the farthest, and should be plowed very soon after the crop is sown, turning the infested plants under and thoroughly covering them. Simple cultivation whereby the plants are only killed, would probably only destroy a portion of the insects, the full-grown larvæ very likely going through the remainder of their transformations.

The application of fertilizers is, I believe, in Ohio as well as Indiana confined to the poorer soils, and there more for its general effect on the crops than as against the effects of insects. The idea in late sowing is to retard the plants so that they do not appear until after the greater part of the fall brood of flies have appeared and died, than to overcome the effect of this delay by aiding the plants to make the greatest possible growth before winter closes in, which will the better enable them to withstand its rigors. In this direction, it would seem that the application of proper commercial fertilizers would pay by the effect upon the growing plants, even though the land itself was not in actual want of such treatment. The application to a field which has previously been seriously damaged, with a view of encouraging the throwing out of fresh tillers, is for practically the same purpose; and if there is a tendency to throw out the later shoots freely, if not too late in the season, many may be enabled to secure sufficient vigor to sustain them until spring. Whether it would be more profitable to plow and resow than to try to secure a crop from the infested field by the aid of fertilizers is, of course, a question which each farmer must decide for himself in accordance with the time of year and extent of injury already done.

These measures are all of them practical and entail little if any unusual expense. In fact, good farming presupposes that the most of them will be carried out as among the essential elements of the business. Where clover is to follow wheat it of course precludes the burning of stubble or the destruction of volunteer plants, but it necessitates the rotation of crop, and decoys can be sown and the seeding delayed. It is hardly possible for a farmer to become so situated that he can not carry out some of these measures, and if this were done generally and every year, the Hessian fly would, in all probability, become of so little importance that it would cease to enter seriously into the problem of successful wheat growing.

There is another measure, which, if carried out, would tend to reduce the severity of the fall attack, in many cases. But the "perversity of human nature," will hardly permit of putting it into practice. I refer to a unanimity in time of sowing, whatever the date may be. If this were done the plants in all fields would appear above ground at about the same

time, and serve to scatter the fly over so large an area, that, though numerous, they would work less injury than if confined to a few fields. If neighborohoods or counties would unite in doing this, much of the present loss by this pest would be saved. As it is, somebody is sure to sow at the wrong time, and thus the species is carried over in great numbers, to work injury the following year.

After thirteen years of study of the Hessian fly (*Cecidomyia destructor*), I am satisfied that four-fifths of its injuries may be prevented by a better system of agriculture. For years I have seen wheat grown on one side of a division fence without the loss of a bushel by attack of this pest, while on the other side the crop was almost invariably more or less injured. No effect of climate, meteorological conditions, or natural enemies could have brought about such a contrast of results. The whole secret was in the management of the soil and the seeding. In fact, the question of success in evading the pest, in the one case, did not appear to be an entomological one at all; and I am fully convinced that the Hessian fly problem, so far as it relates to agriculture, throughout that portion of the country lying between the Allegheny Mountains and the Mississippi River, and between the Ohio River and the Great Lakes, may be considered practically solved.

In conclusion, permit me to make some suggestions as to seeding, even though it may appear beyond the pale of an entomologist. In the first place get good seed. You can not grow healthy wheat plants, that will resist the attack of the fly or any other insect, by sowing shrunken, unhealthy kernels. If you wish fifty bushels of seed take them from out of a hundred, and take only the largest and best grain. Sowing late does not mean putting off the preparation of the ground until the last day, and then hurrying in the crop. Plow early and do not bestow work grudgingly on your field. Get a compact, smooth, well pulverized seed bed at any cost, so that the seed will be evenly covered and not one portion covered six inches deep and other portions one inch deep. Nothing will pay better than this. With every thing in readiness, wait patiently until the fly has emerged, and largely at least, disappeared, then sow your grain as carefully and as well as you would if you were planting your last dollar. In ordinary seasons the sire (seed), with the assistance of mother earth, will give you a growth of sturdy, hardy, thrifty plants that will have dodged the fly, escaped the rust and will go into winter in better condition than if sown early and in a slip-shod manner. In the spring this grain will meet even a quite severe attack of the fly and the effect will partake more of that of the pruning knife than the sickle. Rich soil will of course have the advantage, but if not rich do not abuse it because it is poor, as that is all the more reason for good culture. The army worm, which loves a rank growth, and, possibly, the wheat midge excepted, I know of no wheat destroying insect that will not be placed at a disadvantage by this treatment.

REMEDIES.

After the fly has gained possession of a field, I know of no application that can be made which will destroy it. Doubtless pasturing the field, if early sown, will often result in reducing the numbers of the pest, besides giving to the ground that compact, pulverized nature, which it should have had at the first. No doubt many larvæ and "flaxseeds" by

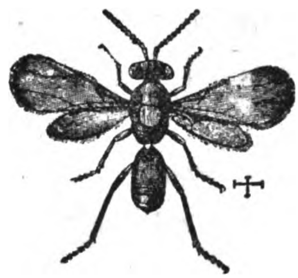


FIG. 11.

this means would be crushed, but very few would enter into the food of the animals grazing thereon, unless the plants were pulled up both stem and roots. In pasturing sheep are preferable to large animals.

NATURAL ENEMIES OF THE HESSIAN FLY.

For America the following species have been recorded:

CHALCIDIDÆ.

Merisus destructor Say. (Fig. 11.)
Bæotomus subapterus Riley.
Pteromalus pallipes Forbes.
Eupelmus alynii French.
Entedon epigonus Walk. (Artificially introduced.)

PROCTOTRYPIDÆ.

Polygnotus hiemalis Forbes.
Platygaster herrickii Packard.

As secondary parasites we may record *Tetrastichus productus* Riley, and *Tetrastichus carinatus* Forbes.

In Russia Dr. Lindemann records the following:

CHALCIDIDÆ.

Merisus intermedius Lindm.
Entedon epigonus Walk. (Semiotellus nigripes Lindm.)
Eupelmus karschii Lindm.
Euryscapus saltator Lindm. (Reared also from galls of *Isosoma hordei*.)
Tetrastichus rileyi Lindm. (Secondary parasite of *Merisus*.)

PROCTOTRYPIDÆ.

Polygnotus minutus Lindm.

In England, Miss Eleanor A. Ormerod and Mr. Fred. Enock have obtained the following parasites:

CHALCIDIDÆ.

Merisus destructor Say.
Bæotomus subapterus Riley
Merisus intermedius Lindm
Entedon epigonus Walk.
Eupelmus karschii Lindm.
Euryscapus saltator Lindm.
Tetrastichus rileyi Lindm.
Tetrastichus. (Two species.)

PROCTOTRYPIDÆ.

Polygnotus minutus Lindm.
Platygaster herrickii Packard.

Dr. Marchal records from *Cecidomyia destructor* the following as being obtained from Vendée, France:

CHALCIDIDÆ.

Merisus destructor Say.
Holcæus cecidomyiæ Ashmead.
Bæotomus rufomaculatus Walk.
Eupelemus atropurpureus Dalm.

PROCTOTRYPIDÆ.

Polygnotus minutus Lindm.
Polygnotus zosini Walk.
Trichasis remulus Walk.

The above lists are taken from a recent bulletin on "The Hessian Fly in the United States," by Prof. Herbert Osborn, this being Bulletin 16, New Series, of the U. S. Department of Agriculture, Division of Entomology.

Referring to these natural enemies Prof. Osborn further states that their importance is probably difficult to over-estimate and that there is abundant reason for a careful consideration of the various species of insects known as attacking Hessian fly, owing to the fact that probably fully nine-tenths of these insects are destroyed by those parasites. I need hardly say that my own studies fully substantiate these statements, and I am satisfied that but for its natural enemies the Hessian fly would render it impossible to grow wheat, successfully, in many sections of the United States. I have included in this paper the lists of such natural enemies as have been reared not only in America but in Russia, England and France. As will be seen at a glance, there is a great similarity between these parasitic enemies in the four countries indicated. I might call attention to the fact that it is very often a curious experience with farmers that the fly will be excessively abundant during one season, while the next it will seem to have almost entirely disappeared. Careful studies

of the fly, at such times, reveal the fact that so very few of them escape the attacks of their natural enemies that the insect is in reality reduced in numbers, almost to the point of extermination; but, at this point, a reduction in the number of natural enemies must necessarily take place, on account of the lack of flies for their support, so that both host and parasite come to the bottom, in point of numbers, and the fly, the following year, being relieved from its enemies, which will die out for want of food, again starts in its progress upward in point of numbers, to be followed later by its enemies. These gradually work upward, until there comes a time when there is an excessive abundance of flies, and these afford ample food for the parasites until the two are again forced to the bottom to start again anew. This has given rise to the oft repeated explanation by the unscientific, that it matters little what insect appears it will be only a question of time when something will occur to destroy it. However, the fact that the insect pest must get to be very abundant, and work serious injury, before its natural enemies can increase sufficiently to destroy it is entirely lost sight of. What is really needed here is man's interference, to prevent the destructive insect from becoming abundant enough to destroy his crops. If we get at this in the right way, we shall be able to keep the Hessian fly so reduced in numbers that its natural enemies will take care of it. But these natural enemies are susceptible to weather conditions, and frequently parasites cannot be relied upon to, always, hold the destructive species in check; but if farmers could only understand the habits of the Hessian fly and its enemies, they would be far better able to so manipulate their crops, in times of plowing and sowing, that the fly would be unable to breed in such overwhelming numbers, and the farmer's insect friends would thus be enabled to hold the depredator in check.

SUMMARY.

The Hessian fly is a small, dusky-colored, two-winged insect, about one-eighth of an inch long. It appears during spring and fall, the former period extending, in Ohio, throughout the month of May and probably the first half of June, and the latter, or fall brood, extending through the last days of August and much of September in the northern part of the State, and the last of September and the first week or ten days in October, in the extreme southern portion of the State. The eggs are deposited in both spring and fall on the upper side of the leaves, and the young, as soon as they hatch, make their way down the plant behind the sheath of the leaves. In the spring, they go down to the first or second joint above the roots, but in the fall, when the plants are much smaller, they usually go down to a point just above the roots, indicated in Figue 9 by letter *a*. The effect on the wheat, in the fall, is to prevent the plant from sending up shoots that would bear heads the follow-

ing year, and to reduce the growth to a mere bunch of rank growing leaves, that kill out during the winter. In the spring, the maggots, or young, go down to the first or second joint above the roots, and there become imbedded in the straw, thus weakening it, and when the grain comes to head, the straw thus weakened will topple over and break down, thus giving rise to what is known as "straw fallen" grain. The insect passes the winter, largely, in the flaxseed stage about the plants, just above the roots. It passes the summer, largely at least, in the stubbles that are left in the fields at harvest. Thus the adults breed in spring and fall at dates varying with the latitude. They live but a few days and die almost immediately after depositing their eggs. The preventive measures are late sowing, rotation of crops and burning of stubble, where this can be done. The remedies consist in the use of quick-acting fertilizers, in the fall, or pasturing early sown fields, preferably with sheep. There is no known remedy against the spring brood of flies.

PUBLICATIONS

OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

A complete list of previous publications of this Station may be found in Bulletin 95. Following are the titles of subsequent bulletins:

No. 96. The Army Worm and other insects; Wheat and Grass Sawflies; the Corn or Boll Worm; the Painted Hickory Borer; the Raspberry Cane Borer; the Peach Scale.
No. 97. Diseases of wheat and oats.
No. 98. Small fruits; cultural notes and comparison of varieties.
No. 99. Sugar beet investigations in 1898.
No. 100. A comparison of factory-mixed and home-mixed fertilizers.
No. 101. Experiments with oats.
No. 102. Soil and seed treatment and spray calendar for insect pests and plant diseases.
No. 103. The San José Scale in Ohio.
No. 104. Further studies upon spraying peach trees and upon diseases of the peach.
No. 105. Further studies of cucumber, melon and tomato diseases.
No. 106. The chinch bug; experiments with insecticides.
No. 107. The Hessian fly.

Ohio Agricultural Experiment Station.

BULLETIN 108.

WOOSTER, OHIO, JUNE, 1899.

BOVINE TUBERCULOSIS.

The Bulletins of this Station are sent free to all residents of the State who request them. Persons who wish their address changed should give both old and new address. All correspondence should be addressed to

EXPERIMENT STATION, WOOSTER, OHIO.

COLUMBUS, OHIO
FRED J. HEER, STATE PRINTER
1899

The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.

Bul. 108

ERRATA.

Page 290, third paragraph, for tubbercle read tubercle.
Page 296, table, for Lorella read Sorella in each case.
Page 299, third line, for round read found.
Page 305, for Lady Tehl read Lady Fehl.
Page 309, unnamed illustration is of Fanny Daw's Second.
Page 337, foot note, for cofumigating read communicating.
Page 338, fourth paragraph, for tuberculosis read tuberculous.
Page 344, table heading, for yaer read year.
Page 364, first line, for tubercular read non-tubercular.
Fage 368, column headings of table, for tuberculos read tubercular, and for death, read deaths.
Page 372, Conclusion 1, for vegetble read vegetable.

BOVINE TUBERCULOSIS.

By C. E. Thorne.

CONTENTS.

ACKNOWLEDGMENTS.

The experiments with tuberculin, reported in the following pages, were made by the Station Agriculturist, Mr. J. Fremont Hickman, with the assistance of Wm. Holmes and C. A. Patton, Farm Foremen, and Antony Russ, Herdsman, the tuberculin itself being furnished by Dr. D. E. Salmon, Chief of the Bureau of Animal Industry, Washington, D. C.

The data concerning the prevalence of bovine tuberculosis and municipal inspection of milk and meat in Ohio have been furnished by one hundred veterinarians and health officers, and those relating to infantile tubercular disease by three hundred and thirty-nine physicians, who have most kindly responded to circulars of inquiry on these points.

The numerous citations from the work of other stations have been acknowledged as made; but the copiously indexed volumes of the Experiment Station Record have been of great service in looking up the general literature of this subject. Running through the ten volumes of this publication there are now more than 200 references to publications on tuberculosis of animals, a large proportion of these references being accompanied with abstracts or summaries.

INTRODUCTION.

Tuberculosis is the generic name given to a class of diseases due to the growth within the body of a vegetable organism — the *Bacillus tuberculosis* — of which class the disease called consumption is the best known type. Tuberculosis is characterized by the deposit of grayish-white granules, which may be the size of a millet seed or smaller, or may be aggregated into larger masses, or tubercles. These masses or granules are at first red, congested and solid; gradually the color changes to gray, as the tissues become dead, and a cheesy mass is usually formed which becomes gritty through deposit of earthy salts and eventually softens into pus. In some cases, instead of forming a cheesy mass, the tubbercle develops into firm, rounded nodules, filled with calcareous deposit.

In cattle the disease frequently makes its first appearance in the pharyngeal, bronchial or mesenteric glands, and it may be confined to a single gland, or set of glands, for an indefinite period, before assuming a more generalized form.

In its first stages it is usually impossible to recognize bovine tuberculosis by ordinary methods of diagnosis. Sometimes the pharyngeal glands become so much affected as to interfere with breathing, when the disease may be suspected; but when the affection is confined to organs more deeply seated it may be months or years before its presence is made evident.

Coughing, which is so generally a symptom of pulmonary consumption in the human subject, is by no means a regular symptom of tuberculosis in cattle. When the lungs become much involved some coughing is to be expected, but in very many cases the liver and other organs may be affected long before the disease reaches the lungs. In fact, an animal may be to all external appearances in perfect health, with sleek coat and increasing weight, and yet be far advanced with tubercular disease.

In 1882 Dr. Robert Koch, of Berlin, demonstrated the true nature

of this disease by isolating the tubercle bacillus, and showing that the disease may be produced with equal certainty by inoculation from tuberculous material, or from pure cultures of this bacillus, grown on gelatine and entirely away from the animal body. He also showed that the tubercle bacillus, as found in the tubercular human subject, is identical in appearance with that found in tubercular animals, and that the disease may be produced at will in animals by inoculation with human tuberculous material.

With Jenner's great discovery in mind, Dr. Koch attempted to produce a substance which should have the effect of rendering the system immune to the tubercle bacillus. To this end he heated tubercular material until the germs were killed and strained it to remove their dead tissues, giving to the clear liquor thus obtained the name "Tuberculin."

His hope that tuberculin would prove a preventive or cure for tubercular disease was doomed to disappointment; but it has proved to be the next best thing, the most effective diagnostic of this disease, especially in its earliest stages, that has ever been discovered.

THE TUBERCULIN TEST.

The value of tuberculin as a diagnostic depends upon its property of causing an elevation of temperature in tuberculous cases in doses which produce apparently no effect whatever upon the healthy organism. In the use of this test upon animals the normal temperature is first ascertained by making several observations with the clinical thermometer; a hypodermic injection is then made of tuberculin of a given strength, the dose being graduated according to age and species of the animal, and after an interval of a few hours the temperature is again ascertained, observations being made at frequent intervals for ten or twelve hours. If a rise of temperature of two or more degrees occurs, beginning within 8 to 16 hours, usually 10 to 14 hours after the injection, and continuing for several hours, then tuberculosis is to be suspected, provided, of course, such sources of error have been avoided as sexual heat, approach of parturition, or undue exposure or excitement.

There are now on record many thousands of cases, both in America and Europe, in which the tuberculin test has been followed by slaughter and post mortem examination, and its diagnosis, whether positive or negative, has been so universally confirmed as to give to this test a place among the most accurate of diagnostics.

The tuberculin test was introduced into the United States in 1892, the tuberculin being imported from Dr. Koch's laboratory. The manufacture of tuberculin was soon undertaken by the Bureau of Animal Industry, U. S. Department of Agriculture, and is still continued by that Bureau, while it has also been undertaken by private firms. The Bureau of Animal Industry cannot sell tuberculin, but will supply it

without charge to public officials who have authority to destroy all animals found tuberculous. The tuberculin used in the investigations of this Station has been supplied by the Bureau, through the courtesy of its efficient chief, Dr. D. E. Salmon.

HOW TO MAKE THE TUBERCULIN TEST.

The essential apparatus foı making the tuberculin test consists of three pieces: the clinical, or fever thermometer, the hypodermic syringe and either a graduated beaker or a graduated pipette. The clinical thermometer may be bought at any first class drug store, but should be accompanied with a certificate of accuracy.

The hypodermic syringe consists of two principal parts, the barrel with its piston, and the needle. It is well to have two needles, in order that one may be disinfected while the other is in use. The needle with a shoulder will be found useful for work on young animals, the shoulder

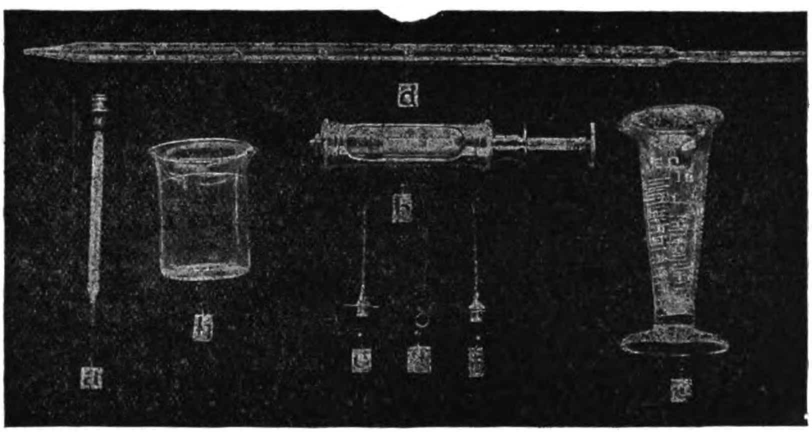


FIG. 1. INSTRUMENTS FOR MAKING THE TUBERCULIN TEST.

a. Clinical thermometer.
b. Hypodermic syringe.
c. Graduated beaker.
d. Graduated pipette.
e, *f*. Injecting needles.
g. Needle cleaner.
h. Small beaker.

preventing a too deep insertion of the needle; but for old animals, with a thick, tough hide, the shoulder is sometimes objectionable, as the point is not quite long enough to penetrate such hides to a sufficient depth to insure a perfect injection and it is not easy to push the needle past the shoulder. The point of the needle is made with cutting edges, which make a cut instead of a punctured hole.

Hypodermic syringes for veterinary use are sold by all dealers in veterinary supplies. Among other equally responsible houses are those of Haussman & Dunn of Chicago and John Reynders & Co. of New York. It is advisable to get nickle plated instruments, as they are less liable to be affected by carbolic acid than rubber mounted pieces.

As between the graduated beaker and the graduated pipette, the latter is much the more accurate instrument, but it requires a little practice to manipulate it successfully. The fluid to be measured is first drawn into the pipette by mouth suction, a finger is then quickly placed upon the upper end of the tube, and the liquid is allowed to flow back into the bottle slowly, by slightly lifting the finger, until the zero point is reached, after which it is permitted to flow into a small beaker (*h*) until the exact quantity required has run out, when the remainder is emptied back into the bottle again. For this purpose a chemist's beaker is much better than a teacup or tumbler, because the flat bottom makes it possible to draw up the liquid completely into the syringe, by tipping the vessel, whereas a rounded bottom would retain more of the fluid.

The graduated pipette, of which the 5 cubic centimeter size, graduated to tenths, is most convenient, may be bought of Eimer & Amend or Emil Greiner, New York, or other equally good houses, if it cannot be found at the local drugstore.

The dose of tuberculin, as prepared by the Bureau of Animal Industry, is 2 cubic centimeters for a thousand-pound cow, or in that proportion for animals of heavier or lighter weight.

After the exact quantity required for the dose has been measured out it is drawn up into the hypodermic syringe, the point of which has been first disinfected by dipping or letting it stand a few minutes in a solution of carbolic acid and then rinsing in pure water. It is well here to have an assistant to hold the beaker at such an angle that the syringe may draw out all the liquid. If the operator is skillful the point of the syringe may then be inserted through the skin — the point of the shoulder is the place usually selected, and it is better for the operator to stand on the opposite side of the animal from that on which the insertion is made, and reach over its back — and the contents carefully forced out, the skin being pinched up and drawn out a little with one hand, in order to prevent the liquid flowing back outside of the needle, while the syringe is manipulated with the other. As the animal is liable to flinch from the sting of the needle, however, it is better, for the amateur operator at least, to unscrew the needle, after filling the syringe, insert the needle first, then screw on the syringe and make the injection.

In filling the syringe care should be taken to avoid getting air into the cylinder, and in emptying it a steady pressure should be used.

As soon as an injection has been made the needle should be unscrewed and placed in a small cup containing a full strength solution

of crystals of carbolic acid, otherwise there may be danger of carrying germs of the disease from one animal to another.

In making the tuberculin test the first step is to determine the normal temperature of the animal. This is done by inserting the clinical thermometer into the rectum and letting it rest about three minutes, then withdrawing and reading carefully. It is well to have a string attached to the thermometer, thus permitting insertion of the instrument to its full length; otherwise it is liable to be broken by the tail. It should also be moistened or oiled before insertion and disinfected afterward. Where many animals are to be tested it will be economy to have two or three thermometers. These preliminary determinations of temperature should be repeated at intervals of two or three hours throughout an entire day. It has been our practice to begin at 6 or 8 o'clock A. M., and repeat the determination every two hours until 10 o'clock P. M., At 10 P. M. the injection is made. Beginning next morning at 6 A. M. the temperature is again read every two hours until 8 or 10 o'clock P. M.

The presence of tubercular disease is indicated by a decided rise in the temperature of the animal, following the injection of tuberculin. Ordinarily this rise of temperature begins within 10 to 14 hours after the injection, although in exceptional cases it may commence earlier or later. In the typical tuberculin reaction the temperature rises gradually until a maximum point from two to four degrees above the normal is reached, when it as gradually subsides again. In advanced cases, or after the test has been made several times, the rise of temperature may not exceed two degrees; but in the case of a fresh test, when there are no outward indications of disease, a rise not exceeding two degrees should not be accepted as sufficient evidence of disease. Care should also be taken to avoid the periods of sexual heat, as these may cause a rise of two or three degrees in temperature and thus entirely obscure the effect of the tuberculin. Other causes of excitement, such as rapid driving, railroad transportation, or removal to strange quarters must also be avoided.

WHY DOES NOT TUBERCULIN PRODUCE FEVER IN THE HEALTHY ANIMAL?

The answer to this question is that it will produce fever if used in sufficiently large quantity. As tuberculin is a product of tuberculous growth, it follows that it is constantly being formed when such growth is taking place, and when the disease reaches its later stages the quantity of tuberculin produced is sufficient to cause the afternoon fever which is one of the characteristic symptoms of this disease, both in human and bovine subjects. While the disease is in its less active form, however, the system becomes gradually accustomed to the presence of the small amount of tuberculin produced, and the time comes when the ordinary dose of tuberculin fails to produce any reaction.

WILL NOT TUBERCULIN PRODUCE TUBERCULOSIS?

There has been a quite general fear that tuberculin might, of itself, produce the disease in a healthy animal, but a careful study of the nature of the disease must show that this fear is unfounded. As has been stated, the researches of Koch, which have been verified by many others, have shown that the disease, tuberculosis, is produced by the growth within the tissues of a living, vegetable organism, which has its laws of reproduction, as definite and fixed as those governing the reproduction of any other forms of life. In the preparation of tuberçulin this organism is first killed by heat, and its dead tissues are then removed from the liquid, so that there is no possibility of transferring the germs of growth through the medium of tuberculin. This theoretical assumption has been verified by countless experiments, in which the tuberculin test has been used repeatedly on healthy animals, with no unfavorable results of any description.

AN OUTBREAK OF BOVINE TUBERCULOSIS AT THIS STATION.

The herd of cattle at this Station was established in 1894, by the purchase of a bull and two or three cows each of the Jersey, Guernsey, Holstein, Red Polled, Shorthorn and Polled Angus breeds. These cattle were all registered and were selected from various parts of the state, not more than one or two animals as a rule being bought of any single breeder.

At the time these purchases were made the idea was prevalent that the tuberculin test might be injurious to the health of the animal.. Many cattle breeders feared that it might be the means of introducing tuberculosis into their herds, while others, better informed on this point, still were forced to admit that the possible after affect, upon the general health of the animal, of the introduction of a toxic poison, like tuberculin, was at that date unknown, since the tuberculin test had only been introduced into this country two years previously. For this reason the test was not insisted upon in the purchase of these cattle, but every other precaution was taken to secure sound animals.

On the Station farm they were, of course, given good care. They were kept in newly built stables, which were warm, and in our judgment were sufficiently ventilated. All the increase was retained, and by the spring of 1897 there were about 80 animals in the herd, all apparently in perfect health except two—a Shorthorn cow and a Jersey bull, which had begun to show evidences of disease; the cow by rapid loss of flesh, and the bull by the growth in the throat of a visible lump, which caused difficulty in breathing.

At the beginning of June both these animals were killed, after having been subjected to the tuberculin test. The cow was found to be in the

last stages of generalized tuberculosis, and the lump in the bull's throat was found to be due to the same disease. A supply of tuberculin was then procured from Dr. D. E. Salmon, Chief of the Bureau of Animal Industry, and on June 15 to 17, thirty animals were subjected to the tuberculin test, with 14 cases of reaction. On September 7 and 8 these 14 animals were re-tested, with reactions in every case. In December and January further tests were made, and on June 8, 1898, fifteen cattle were slaughtered under the inspection of an officer of the Bureau of Animal Industry.

TABLE I—TUBERCULIN RECORD OF CATTLE

No.	Name.	Age years.	Temperature before injection.								
			Date.	8 a. m.	10 a. m.	12 m.	2 p. m.	4 p. m.	6 p. m.	8 p. m.	10 p. m.
1	Ohio's Vexer	4	May 24, '97	101.	101.	101.	101.5	103.	**104.2**	**107.**	**104.8**
2	Lady Challenger 2nd	6	May 24, '97	102.5	103.	103.5	103.8	**104.**	**104.**	**104.8**	**104.8**
3	Portia..............	6	June 15, '97	.....	100.2	101.	101.2	101.2	101.5	101.8	102.
			Sept. 7, '97	99.6	99.2	100.4	101.	101.	101.	101.	103.
			May 23, '98	102.2	102.6	103.6	102.8	103.6	103.	102.2	103.6
4	Viola..............	6	June 15, '97	.....	101.	101.2	102.5	102.	102.4	102.2	102.2
			Jan. 10, '98	101.8	102.6	102.	102.4	102.	101.2	101.2	101.6
			May 23, '98	101.2	102.	101.8	102.	102.	102.	102.	101.8
5	Nightingale	10½	June 15, '97	.....	101.2	101.8	101.8	102.6	102.6	102.8	102.4
			Dec. 28, '97	102.6	103.8	103.2	103.6	102.2	102.2	102.4	102.
			May 23, '98	101.4	101.8	101.8	102.	102.6	101.6	102.6	101.6
6	Fanny Daw 3d......	6	June 15, '97	.....	101.2	101.	101.2	102.4	102.6	102.2	101.6
			Dec. 28, '97	101.6	102.8	101.4	102.8	99.	.....	100.8	100.6
			May 23, '98	101.8	101.8	101.8	102.2	102.6	101.	101.4	102.2
7	Nervilette	7	June 17, '97	101.	101.	101.	101.	100.2	101.8	101.	101.4
			Sept. 7, '97	99.4	100.4	101.	101.8	102.	102.4	102.2	101.8
			May 23, '98	101.	101.8	101.8	101.8	102.	100.4	100.6	100.
8	Nervilette's First ..	2	June 15, '97	.....	101.	101.5	101.5	101.5	102.	102.4	101.8
			Sept. 7, '97	100.6	100.6	100.8	101.8	102.	101.6	102.2	102.2
			May 23, '98	101.6	102.	102.4	102.8	102.6	100.8	101.8	101.2
9	Lorella....	7	June 17, '97	101.6	101.2	101.4	102.	100.8	101.6	101.	101.2
			Sept. 7, '97	101.	101.4	101.	101.2	102.	101.8	102.2	102.
			May 23, '98	102.	101.4	101.6	101.6	102.6	101.6	102.	101.4
10	Lorella's First	3½	June 17, '97	101.2	101.2	101.6	101.	101.4	101.	102.	101.
			Sept. 7, '97	100.6	101.2	101.	101.2	101.4	102.6	102.6	102.4
			May 23, '98	101.8	101.8	102.6	102.6	102.6	103.	102.2	102.6
11	Lorella's Second...	2½	Dec. 22, '97	99.8	101.4	101.4	101.6	100.8	101.4	101.	100.2
			May 23, '98	101.2	101.6	102.	102.	102.6	102.2	101.4	102.
12	Miami's First.......	3	June 17, '97	101.6	101.8	102.	102.	101.6	102.	102.2	102.
			Sept. 7, '97	100.4	101.2	101.2	101.	101.2	102.	102.2	102.
			May 23, '98	101.	101.8	102.	102.	102.6	101.8	101.2	101.6
13	Peterina's Second...	3	June 17, '97	.....	.....	.....	102.2	102.2	102.	101.8	101.6
			Sept. 7, '97	101.	101.	101.	101.2	101.4	101.6	101.2	101.
14	Jolly Boy..........	4	June 17, '97	.....	.....	.....	101.4	101.2	101.2	101.	101.
			Sept. 7, '97	100.	99.	99.	99.8	101.	100.6	100.	100.2
15	Levi Tom	4¾	June 17, '97	.....	.....	.....	102.2	102.2	102.2	102.	102.
16	Fancy's First......	2½	Dec. 22, '97	102.4	103.2	102.8	103.	102.4	102.4	102.6	102.4
17	James' Cow....		June 15, '97	.....	101.	101.	101.	101.2	101.4	101.6	101.4
18	Mahomet's Rur'l Lass	9	June 15, '97	.....	101.	101.6	101.8	102.4	103.	103.2	103.4
19	Orphia 2nd.... ...	8	June 15, '97	.....	101.	101.4	101.2	101.6	101.6	102.	102.
			May 23, '98	101.6	101.2	102.2	102.2	102.	101.2	102.	101.8
20	Teeny's Fancy ...	6	June 17, '97	101.6	101.	101.2	101.	101.	102.	101.	101.4
21	Miami's Fifth......	5 mos.	July 12, '98	103.4	102.2	104.	103.4	103.4	103.2	103.6	.....
22	T. S. Miami..	4 mos.	July 12, '98	103.2	102.6	102.6	102.6	102.4	103.	102.6	.....
23	Phillips' calf		Aug. 29, '98	102.	102.8	103.	102.6	102.4	103.	103.	....
24	Nightingale's Fourth	3 mos.	July 18, '98	105.0	104.6	104.6	105.0	105.0	105.4	105.0	....

Table I gives the tuberculin record of the two cattle first killed at the Station, of the 15 killed in June and of several other animals upon which there has been opportunity to test the accuracy of the tuberculin diagnosis by post mortem examinations.

NOTES.

Ohio's Vexer: Jersey bull, 4 years old. The temperature record shows an abnormal elevation in the afternoon previous to the injection of tuberculin,

KILLED PREVIOUS TO APRIL 11, 1899.

Date.	Temperature after injection. 6 a. m.	8 a. m.	10 a. m.	12 m.	2 p. m.	4 p. m.	6 p. m.	8 p. m.	10 p. m.	Live weight at slaughter.	No.
May 25, '97	101.2	102.2	104.2	106 8	107.	106.5	106.	105.5	104.	....	1
May 25, '97	104.8	104.2	104.	104.	104.2	104.2	103.5	104.	103.5	....	2
June 16, '97	100.8	100.6	101.6	102.	105.4	104.	103.8	103.2	....	....	3
Sept. 8, '97	100.6	100.8	102.	104.4	105.4	105.2	103.8	103.	102.8	....	
May 24, '98	101.8	101.8	103.6	103.8	105.4	105.8	106.	105.4	104.6	1379	
June 16, '97	101.	101.2	102.2	101.4	101.2	101.2	101.8	.....	.....	....	4
Jan. 11, '98	101.4	101.8	102.	103.2	104.2	105.2	105.	104.8	104.6	....	
May 24, '98	101.4	102.	102.	101.8	101.6	101.6	102.	102.	101.8	1053	
June 16, '97	101.5	101.	101.8	101.6	101.	102.	102.4	.....	...	....	5
Dec. 29, '97	102.8	105.	107.4	107.4	105.8	103.	104.6	105.4	105.	....	
May 24, '98	102.8	104.8	107.	106.8	105.6	104.6	104.8	104.8	105.	942	
June 16, '97	101.2	101.2	101.	101.	101.4	102.	102.2	.....	.....	....	6
Dec. 29, '97	101.2	101.4	102.8	103.8	106.	104.8	103.2	102.4	102.	....	
May 24, '98	101.6	101.2	102.4	103.2	103.8	102.8	102.4	102.2	102.	1186	
June 18, '97	101.	101.2	101.2	102.6	105.	104.	104.2	105.2	.....	....	7
Sept. 8, '97	104.6	106.	106.2	105.8	106.6	105.6	105.	105.	104.	....	
May 24, '98	101.4	102.6	105.	106.2	104.8	103.2	103.8	104.2	104.8	707	
June 16, '97	105.	104.8	105.2	105.8	104.	105.6	105.	103.6	....	....	8
Sept. 8, '97	105.	106.4	106.	105.6	105.	106.6	107.4	106.8	106.	....	
May 24, '98	102.8	104.	106.8	107.	105.6	104.6	103.6	104.8	105.4	760	
June 18, '97	101.2	102.	102.8	103.	103.6	103.	102.4	102.	.....	....	9
Sept. 8, '97	102.4	102.4	102.6	103.8	104.6	104.2	103.8	103.8	103.	....	
May 24, '98	101.2	101.2	103.4	106.2	106.8	106.	104.	104.2	102.	1154	
June 18, '97	102.	103.4	104.	105.8	105.2	105.	102.6	103.	....	....	10
Sept. 8, '97	105.2	105.8	106.	105.6	105.4	105.4	104.4	103.	102.	....	
May 24, '98	101.6	102.2	104.4	106.4	105.8	106.	104.	103.6	102.8	970	
Dec. 23, '97	105.	106.3	107.	105.2	106.4	105.6	106.	105.4	104.	....	11
May 24, '98	104.6	106.2	104.2	104.	105.	105.	104.2	104.	104.8	949	
June 18, '97	101.8	104.8	105.6	104.2	104.	104.	105.8	103.4	.....	....	12
Sept. 8, '97	103.6	103.6	104.	103.4	103.4	103.6	103.6	103.	102.6	757	
May 24, '98	101.4	101.4	102.2	104.2	105.6	105.4	105 4	105.6	105.4	....	
June 18, '97	103.4	104.6	105.	103.	106.6	105.2	104.8	106.	....	....	13
Sept. 8, '97	103.	104.2	105.4	106.	105.8	105.	105.6	105.2	103.6	1910	
June 18, '97	102.	103.6	103.8	105.4	106.	105.8	104.	104.8	....	....	14
Sept. 8, '87	100.	101.2	103.	104.	105.2	105.2	105.6	104.8	104.	1750	
June 18, '97	101.4	101.2	101.2	101.8	102.	102.	101.6	101.4	.....	1435	15
Dec. 23, '97	102.4	103.2	104.4	104.8	106.4	104.2	105	104.8	104.6	1129	16
June 16, '97	101.2	100.6	101.4	101.	101.	101.	101.6	.....	.....	....	17
June 16, '97	101.2	101.8	100.6	101.6	102.	102.8	102.4	.....	.....	....	18
June 16, '97	100.6	101.	102.2	102.2	102.6	102.6	102.	.....	.....	....	19
May 24, '98	101.4	101.6	102.2	102.4	102.4	102.6	102.4	103.	102.	....	
June 17, '97	101.	101.	101.6	101.	101.	100.8	101.4	101.2	.....	....	20
July 13, '98	.....	105.	104.2	105.4	104.	104.2	104.8	104.2	.....	....	21
July 13, '98	.....	104.8	105.2	105.4	105.4	105.8	105.6	105 2	.....	....	22
Aug. 30, '98	.....	103.8	104.2	106.4	106.2	106.2	106.4	106.8	.....	....	23
July 19, '98	.....	104.6	103.0	104.2	104.6	105.	104.8	104.8	.....	....	24

which was exceeded in duration, but not in elevation, on the day following. The case was one in which the disease was making rapid progress, and diagnosis by physical inspection was easy, although the animal was still fat.

Lady Challenger 2nd: Shorthorn cow, 6 years old. In this case there was the same abnormal temperature before injection as that noted afterwards, the only difference being that the fever began earlier in the day on the day following the injection of tuberculin. In this case the disease was in its last stages, the animal being at the point of death. The daily afternoon fever noted in these two cases is a common symptom of the later stages of consumption.

Portia: Polled Angus cow, 6 years old at first test. This cow gave the distinct tuberculin reaction at each of the three tests made. The autopsy showed tubercular disease in the post-pharyngeal, bronchial and mediastinal glands, in the liver, stomach and right side of udder. Carcass condemned.

Viola: Red Polled cow, 6 years old at first test. This cow gave no reaction at the first test but showed a plain reaction at the second test. On May 24 she again failed to react, and when killed was found affected in the bronchial and lymphatic glands only, and the carcass was passed as sound.

Nightingale: Shorthorn cow, about 10½ years old at first test. This cow passed the first test but gave decided reactions at the two tests following. Tubercular nodules were found in both lungs and on bronchial and mediastinal glands and lymphatics. Carcass condemned.

Fanny Daw 3rd: Holstein cow, 6 years old at first test. This cow passed the first test, gave distinct reaction at the second, and showed a slight rise of temperature at the third. She was found to be tuberculous in the post-pharyngeal glands, lymphatics, bronchial glands and left lung. Carcass condemned.

Nervilette: Jersey cow, 7 years old at first test. Reacted distinctly at each of the three tests and found tuberculous in left lung, bronchial and prepectoral glands, mediastinal glands badly diseased, small intestines and both pleural surfaces affected. Carcass condemned.

Nervilette's First: Jersey cow, 2 years old at first test. Gave marked reactions at each test and found affected in the post pharyngeal glands, lymphatics, bronchial glands, anterior lobe of left lung, mediastinal glands and left pleural surface, with two abscesses on liver. Carcass condemned.

Sorella: Guernsey cow, 7 years old at first test. Passed the first test with but slight rise of temperature, but gave distinct reactions at both the following tests. Right lung badly diseased, and tubercles on post-pharyngeal, prepectoral and mediastinal glands, liver and both pleural surfaces. Carcass condemned.

Sorella's First: Guernsey cow, 2 years old at first test. Reacted distinctly at each test and found affected in intestinal, lymphatic and mammary glands; peritoneum and liver badly diseased. Carcass condemned.

Sorella's Second: Guernsey heifer, 2½ years old at first test, made December 23-24. Gave distinct reaction at this test and again in May, and found tuberculous in post-pharyngeal, prepectoral and mediastinal glands, lung tissue and intestines, large and small. There were three abscesses on lungs and a large quantity of pus in liver. Carcass condemned.

Miami's First: Guernsey cow, 3 years old at first test. Reacted distinctly at the first and last test, with a considerable rise of temperature at the second test. Found tuberculous in lymphatics, mediastinal glands, stomach, small and large intestines, left peritoneum and right pleura, with abscess and nodules on spleen. Carcass condemned.

Peterina's Second: Holstein bull, 3 years old at first test. Reacted distinctly in June and September, 1897. Killed in June without further testing, and found tuberculous in posterior mediastinal glands only.

Jolly Boy: Red Polled bull, 4 years old at first test. Gave well marked reactions at the tests of June and September. Killed in June without further testing and round tuberculous in bronchial glands and both lungs. Carcass condemned.

Levi Tom: Guernsey bull, nearly 5 years old at first test. Passed the test of June, 1897, as sound. Killed without further test and found affected in submaxillary glands. In this case there had been ample time for infection to take place between the test and the slaughter.

Fancy's First: Polled Angus cow, 2½ years old when tested, December 22-23, 1897. Reacted distinctly to the test, and found tuberculous in bronchial glands only.

James cow: A grade cow, of unknown age, fattened for beef. Tested in June, 1897, without reaction, and found free from tuberculosis when killed a year later.

Mahomet's Rural Lass: Holstein cow, 10 years old at the test of June, 1897, which she passed without reaction. This cow died on January 1, 1898, after having been sick about 4 weeks, and down nearly two weeks. On autopsy the gall bladder was found much enlarged but no sign of tubercle was discovered.

Orphia 2nd: Holstein cow, 8 years old at first test. Passed the tests of June, 1897, and May, 1898, without reaction, but died the first week in October, 1898, with symptoms similar to those shown by Mahomet's Rural Lass.

Teeny's Fancy: Jersey cow, 6 years old. Passed the test of June, 1897, without reaction, but died of parturient fever the following August. Careful autopsy was made but no sign of tubercular trouble was found.

Miami's Fifth and T. S. Miami: These were two Guernsey calves from tuberculous dams (Miami's Maid and Miami's First). They sucked for three days after birth and were then fed on pasteurized milk. They were killed July 16, 1898, when 5 and 4 months old, and both were found tuberculous in pharyngeal and bronchial glands, and the latter also in mediastinal glands, lungs and pleura.

Phillipps calf: A grade Jersey bull calf, from a cow which has never reacted to the tuberculin test. The calf was dropped May 28, 1898, and fed for four months on the untreated milk of the tuberculous cows. The calf was then killed and a large mass of tubercle was found on the pharyngeal glands, but no indications elsewhere.

Nightingale's Fourth: A Shorthorn calf, killed because of the high temperature shown both before and after the injection of tuberculin on July 18, but no tuberculous lesions were found.

The general condition of the 14 tuberculous cattle killed June 8, 1898, is indicated by Table II, which gives their monthly gain or loss in live weight for the 5 months preceding the slaughter, their weight on May 30 and the yield of milk from the cows on May 10.

In selecting the cattle for the slaughter test of June 8, seven cows and a bull, which had reacted to the tuberculin test, were reserved for further investigation. These cattle were kept separate from the remainder of the herd and were subjected to the tuberculin test at intervals of one or two months from that time until April, 1899. When these animals were thus set aside they were apparently all in good condition, showing no outward sign of disease.

One of the cows, however, "Miami's Maid," a Guernsey, 7 years old, soon began to show signs of ailing. She became very much emaciated, while her udder became swollen and very hard. She finally got

down and was unable to get up and was killed the 12th of August. The udder was found to be nearly a solid mass of tuberculous growth, and the lungs and pleural surfaces were also affected.

The tuberculin record of this cow is given in Table III. It will be observed that she gave well marked reactions to the tuberculin test in June and September, 1897, but that in the tests of May and June, 1898, there was an elevation of several degrees in temperature in the afternoon previous to the tuberculin injection, and a similar elevation the following

TABLE II—CONDITIONS OF CATTLE SLAUGHTERED JUNE 8, 1898.

No.	Breed.	Age at slaughter.	Monthly gain or loss (—) in live weight.						Weight May 30, 1898.	Milk yield May 10, 1898.	Extent of disease at autopsy.
			Jan.	Feb.	Mch.	Apr.	May	Total.			
		Years	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	
3	Polled Angus.	7	15	71	10	....	18	114	1379	12	Gen'lized.
4	Red Polled ...	7	46	10	-8	....	-39	8	1053	30	Local.
5	Shorthorn....	11½	103	20	33	*	-57	99	942	23	Gen'lized.
6	Holstein......	7	22	67	56	27	21	193	1186	45	"
7	Jersey	8	.....	4	15	11	-38	-8	707	21	"
8	Jersey........	3	24	.....	22	26	-3	69	760	16	"
9	Guernsey.....	8	42	27	26	55	2	152	1154	12	"
10	"	4½	34	54	42	20	21	171	970	10	"
11	"	3½	69	42	34	34	.....	179	949	20	"
12	"	4	26	14	.....	26	13	79	757	16	"
13	Holstein......	4	47	97	94	28	14	280	1910	.....	Local.
14	Red Polled ...	5	23	65	49	34	40	211	1750	....	Gen'lized.
15	Guernsey....	5½	28	-2	9	63	-8	90	1435	.....	Local.
16	Polled Angus.	3½	....	77	68	37	-8	174	1129	9	Local.

* Dropped a calf.

afternoon, indicating that the disease had by this time progressed to a point where the afternoon fever of consumption was becoming manifest. On February 6, another cow of this lot, May of Edgewood, a Jersey 8½ years old, was killed when in the last stages of puerperal fever, and was found to be tuberculous in both lungs, with considerable cheesy matter and pus and a large abscess in the right lung. The tuberculin record of this cow is given in Table IV, and in this case we have similar symptoms to those shown by "Miami's Maid." In the tests of the first year we have the characteristic tuberculin reaction, but in the later tests this reaction is more or less obscured by the general tendency to increase of temperature, especially of afternoons.

On April 11, 1899, the remaining 6 animals of this lot, together with 5 others which had either reacted distinctly to the tuberculin test or had shown a rise of temperature in the test which left us in doubt as to their

condition, were killed in a public slaughter on the Station grounds, to which veterinarians and other interested had been invited. The tuberculin record of these animals is given on the following pages, as also their condition, as found on autopsy by Dr. David S. White, Dean of the College of Veterinary Medicine, Ohio State University, who conducted the post mortem examinations at the request of the Station.

TABLE III—No. 25—MIAMI'S MAID: Guernsey cow; 6 years old at first test.

Date.	Temperature before injection.								
	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average.
1897, June 17	101.	101.6	101.	102 2	101.6	101.2	102.2	102.	101.6
1897, Sept. 7.......	100.	101.	101.	101.4	101.2	101.4	102.	102.	101.2
1898, May 23......	101.	101.8	102.	102.2	**104.8**	**104.2**	**104.2**	102.8	102.6
1898, June 30	101.4	101.2	101.4	101.8	102.2	**103 2**	**103.6**	**103.2**	102.2

	Temperature after injection.									
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1897, June 18.	103.6	102.	102.8	**104.2**	**104.4**	**104**.	102.2	101.4	......	....
1897, Sept. 8.	103.8	**104**.	**104**.	**104.6**	**103.8**	103.	102.8	102.8	.....	....
1898, May 24.	100.8	101.4	101.6	102.6	102.	102.2	103.4	**104**.	**104.4**	....
1898, July 1..	....	102.	102.4	101.6	101.4	101.6	102.4	**104.6**	**104**.	....

TABLE IV—No. 26.—MAY OF EDGEWOOD: Jersey cow, 7 years old at first test.

Date.	Live weight.	Temperature before injection.								
		8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average
1897, June 17.	....	100.4	101.2	101.	101.6	101.4	101.	101.6	101.	101.2
Sept. 7.	.....	100.8	100.8	101.	101.8	102.2	102.2	101.	103.	101.6
1898, May 23.	849	100.8	101.	102.	102.	102.	100.8	101.2	100.4	101.3
June 30.	880	101.2	101.8	101.6	101.4	101.4	102.6	102.4	102.2	101.8
Aug. 29.	.....	102.2	102.	103.2	102.4	102.2	103.	102.8	......	102.5
Oct. 3.	927	101.2	102.4	102.2	103.4	**104.4**	**104.8**	**104.6**	**104.**	**103.4**
Oct. 31.	943	101.4	102.4	102.4	**103.**	**103.**	**103 4**	**103.**	**103.**	102.7
Dec. 2.	997	102.8	102.8	102.2	102.8	**103.2**	102	102.6	102.4	102.6
1899, Jan. 2.	996	101.6	101.6	102.	102.6	101.6	101.8	102.2	102.8	102.
Feb. 2.	995	....	....	...	102 4	102.2	**103.**	102.	101.4	102.2

	Temperature after injection.									Quantity injected.
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1897, June 18.	99.	102.2	100.8	103.2	**104.**	**106.**	**105.2**	101.	......	2 c. c.
Sept. 8.	103.8	**104.2**	**104.**	103.8	103.8	103.4	103.8	103.8	103.	2 c. c.
1898, May 24.	102.2	**104.4**	**106.6**	**106.2**	103.6	102.2	103.2	101.4	101.2	2 c. c.
July 1.	.....	101.8	102.8	102.	102 6	103.4	**104.6**	**105.2**	103 8	2 c. c.
Aug. 30.	......	101.	101.2	102.2	102.2	103.6	**104.8**	**105.**	......	2 c. c.
Oct. 4.	......	101.	101.8	101.8	102.	102.8	103.2	103.2	103.4	2 c. c.
Nov. 1.	.....	102.	**104.**	103.2	103.	102.8	103.	103.4	103.	2 c. c.
Dec. 3.	......	102.8	103.	**104.**	103.8	103.2	103.4	103.2	102.4	2 c. c.
1899, Jan. 4.	......	102.	103.	103.	**104.**	103.4	103.	103.4	103.8	2½ c. c.
Feb. 3.	......	102.	101.6	101.8	101.6	101.6	102.	101.4	101.	3 c. c.

TABLE V—No. 27—GRETTA THORNE'S FIRST: Holstein cow, 3 years old at first test.

Date.	Live weight.	Temperature before injection.								
		8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average
1897, June 15.	......	......	101.	101.2	101.8	101.8	102.2	102.4	101.8	101.7
Dec. 28.	867	102.	101.4	102.8	100.	102.	101.2	101.8	101.	101.5
1898, May 23.	1102	101.8	102.2	101.8	101.4	101.6	102.	102.	102.8	102.
June 30.	1198	100.8	100.4	101.6	102.	102.4	**103.4**	**103.4**	102.6	102.1
Aug. 29.	.....	102.	101.2	102.	102.2	102.8	**103.2**	**104.**	......	102.5
Oct. 3.	1256	101.8	101.6	102.4	**103.4**	**104.6**	**103.8**	**104.2**	**103.**	**103.1**
Oct. 31.	1232	101.6	102.	102.8	102.8	**103.4**	102.6	101.6	101.4	102.2
Dec. 2.	1011	102.2	102.4	102.	102.8	101.4	101.4	101.2	100.6	101.7
1899, Jan. 2.	1003	100.8	101.4	102.	**103.**	101.	101.	101.4	101.2	101.5
Feb. 2.	961	102.	101.8	102.2	102.2	100.	101.2	101.	100.6	101.4
Mch. 2.	1004	102.	102.6	102.6	102.4	**103.**	102.	102.	101.4	102.2
Mch. 28.	1017	101.4	101.4	101.2	101.4	101.6	102.	101.2	101.2	101.5

Date.	Temperature after injection.									Quantity injected.
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1897, June 16.	101.2	101.6	101.8	101.6	102.	102.	102.4	......	......	2.0 c. c.
Dec. 29.	101.6	102.6	**104.**	**105.4**	**104.**	100.6	101.	101.4	101.8	2.0 c. c.
1898, May 24.	101.4	102.	102.2	102.	101.8	101.6	102.6	101.8	102.	2.0 c. c.
July 1.	.....	101.2	101.8	101.6	102.8	102.2	103.4	**104.**	**104.**	2.0 c. c.
Aug. 30.	101.2	101.2	102.8	102.4	103.	103.4	......	103.	......	2.0 c. c.
Oct. 4.	......	102.2	102.	102.8	102.6	103.	103.2	104.	103.4	2.0 c. c.
Nov. 1.	......	101.	101.6	101.8	102.	101.4	101.6	......	.....	2.0 c. c.
Dec. 3	......	101.4	102.8	102.2	103.	101.2	102.	101.4	101.2	2.0 c. c.
1899, Jan. 3.	......	101.6	102.	102.8	103.4	102.8	102.4	103.4	102.8	2.5 c. c.
Feb. 3.	......	102.	102.4	102.8	103.6	103.2	**104.**	**104.2**	**104.**	3.0 c. c.
Mch. 3.	......	101.8	101.8	101.6	101.6	101.8	102.	101.8	101.	3.0 c. c.
Mch. 29.	......	101.4	102.	101.2	101.4	101.2	101.8	101.6	101.2	3.0 c. c.

No. 27 dropped a calf December 2, 1897, and another November 1, 1898. On December 29, 1897, she apparently gave a clearly marked reaction to the tuberculin test. In the tests of May 23–24, following, there was no evidence of reaction, but in the next three tests there were abnormal afternoon temperatures, both preceding and following the tuberculin injection, and again in that of February 2–3, 1899, there was a distinct reaction. The autopsy revealed no indication of tubercular or other disease, and we must conclude either (1) that the test had failed in this case or (2) that the disease was actually present, but was overlooked, (the brain was not examined) or (3) that the cow had suffered an attack of the disease but had recovered.

TABLE VI—No. 28—LADY FEHL: Shorthorn cow, 9 years old at first test.

Date.	Live weight.	Temperature before injection.								
		8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average.
1897, June 15.	......	... .	101.	101.5	101.8	102.4	102.6	102.2	102.	101.9
Sept. 7.	......	99.	98.8	99.4	101.	100.6	101.	101.	101.	100.2
Dec. 28.	1151	102.6	101.4	103.	101.6	....	......	100.8	101.	100.5
1898, May 23.	1294	101.2	102.	101.4	101.6	102.4	101.2	102.	101.8	101.7
June 30.	1410	101.6	101.6	101.6	101.6	102.2	102.6	102.8	102.8	102.1
Aug. 29.	......	101.4	101.6	101.6	101.8	102.6	103.2	103.	......	102.2
Oct. 3.	1409	101.4	103.4	102.2	103.2	102.6	102.4	103.	103.4	102.7
Oct. 31.	1422	102.2	101.8	102.	102.	102.4	102.8	102.	102.4	102.2
Dec. 2.	*1250	101.4	101.6	101.8	102.2	101.4	101.6	101.2	101.2	101.5
1899, Jan. 2.	1234	101.6	101.	101.6	101.8	102.4	102.	101.2	101.6	101.6
Feb. 2.	1180	101.	101.6	101.8	102.4	101.6	101.4	101.	101.4	101.5
Mch. 2.	1220	102.2	102.2	102.	102.6	102.6	102.4	102.	102.4	102.3
Mch. 28.	1266	101.8	101.2	101.	100.8	101.2	10.3	101.8	101.8	101.6

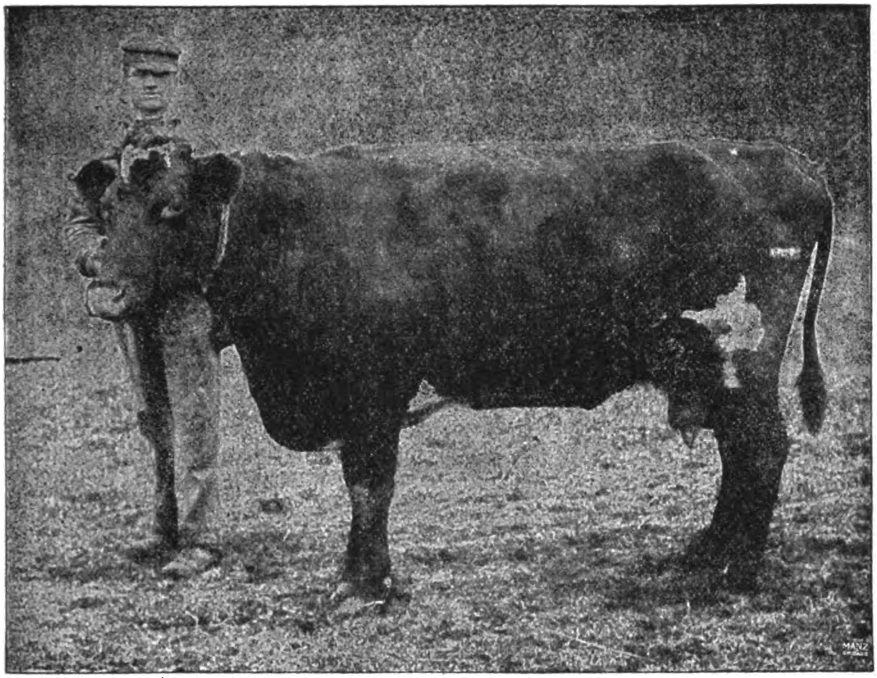
	Temperature after injection.									Quantity injected.
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1897, June 16.	101.	101.6	101.3	103.8	**104.8**	102.2	**104.**	**104.**	......	2.0 c. c.
Sept. 8.	101.8	102.8	**104.**	**105.6**	**105.8**	**105.8**	**105.**	**105.2**	**104.**	2.0 c. c.
Dec. 29.	101.6	102.8	**105.**	**105.8**	**106.**	102.	103.8	103.6	103.	2.0 c. c.
1898, May 24.	101.2	101.6	103.	**104.4**	**105.2**	**105.2**	**104.2**	**104.4**	**104.**	2.0 c. c.
July 1.	......	101.6	101.2	101.8	101.8	101.8	102.8	103.4	103.4	2.0 c. c.
Aug. 30.	101.2	101.	101.6	102.4	102.8	**105.**	......	103.	......	2.0 c. c.
Oct. 4.	......	101.6	101.6	101.6	101.4	102.	102.	**104.2**	103.	2.0 c. c.
Nov. 1.	......	101.6	103.4	102.2	102.8	103.4	**104.4**	103.6	103.8	2.0 c. c.
Dec. 3.	......	101.4	102.2	102.6	102.4	101.8	102.2	103.6	102.2	2.0 c. c.
1899, Jan. 3.	......	101.8	102.2	102.6	102.6	102.6	103.	102.8	102.4	2.5 c. c.
Feb. 3.	......	101.4	101.8	102.4	102.	101.6	102.	102.	101.4	3.0 c. c.
Mch. 3.	......	101.4	102.	101.8	102.2	103.2	103.4	102.4	102.2	3.0 c. c.
Mch. 29.	......	102.	102.	102.	102.8	102.2	102.4	102.8	102.4	3.0 c. c.

* Calves were dropped Oct. 19, 1897, and Nov. 21, 1898.

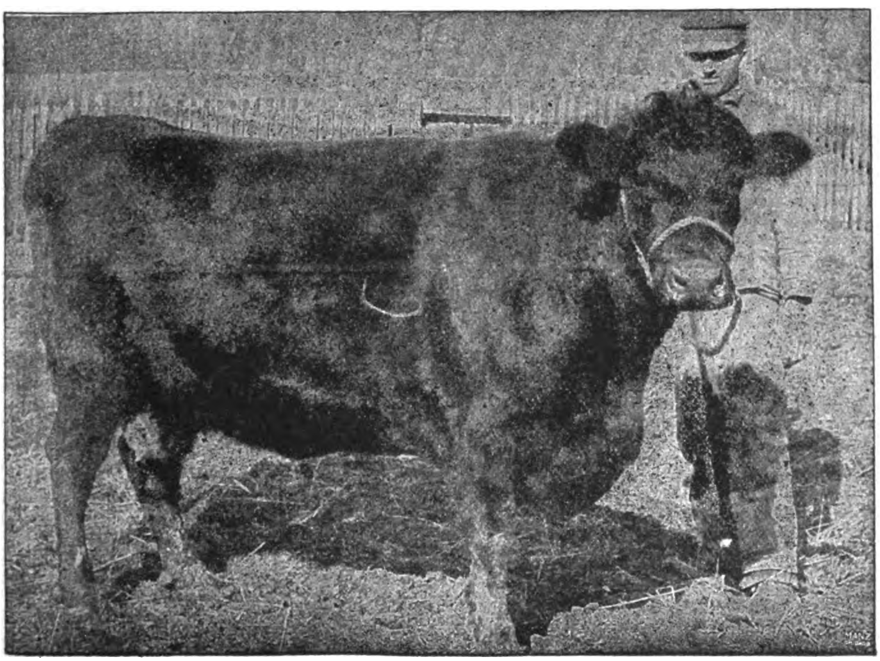
In the case of No. 28 there was a well marked reaction at each of the four tests made during the first year, followed by an afternoon rise in temperature of one to two degrees, both before and after the test, at the next three tests. For the last five months, however, the records show but little variation in temperature, except a slight rise following the test on January 3 and March 3, notwithstanding the increase in the dose of tuberculin.

On autopsy tubercles were found in the retro-pharyngeal, mesenteric, bronchial and post-mediastinal glands (encapsuled in the bronchial glands) in the lower lobe of each lung and on both pleural surfaces. An abscess was found under the diaphragmatic peritoneum.

The cow had been in good condition and was increasing in weight, as shown by the table.



LADY TEHL



VANITY LASS

TABLE VII—No. 29—PATTI: Red Polled cow, 7 years old at first test.

Date.	Live weight.	Temperature before injection.								
		8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average.
1897, June 15.	......	......	101.	101.2	101.8	101.4	101.6	102.2	102.4	101.7
Sept. 7.	......	100.	100.	100.8	101.2	101.4	102.2	101.8	102.2	101.2
1898, Jan. 10.	1103	101.8	102.	100.8	102.	101.8	102.	101.4	101.2	101.6
May 23.	1096	101.2	101.6	101.6	102.	102.	101.2	101.2	101.8	101.8
June 30.	1146	101.6	101.8	102.	101.8	101.8	102.2	102.8	102.4	102.
Aug. 29.	......	101.6	101.2	101.6	102.	102.6	102.4	103.	......	102.1
Oct. 3.	1180	101.4	101.6	101.8	101.6	102.4	102.8	103.4	103.	102.2
Oct. 21.	1205	101.	102.	102.	101.6	102.2	102.	101.6	101.6	101.7
Dec. 2.	1224	102.2	102.6	101.8	102.	101.6	102.8	102.4	102.4	102.2
1899, Jan. 2.	1288	101.	101.6	102.	101.4	101.8	102.2	101.6	101.2	101.6
Feb. 2.	1275	102.	102.	102.4	102.4	101.6	102.4	102.	101.	102.
Mch. 28.	1021	101.6	101.6	101.2	101.4	102.	102.2	102.	101.8	101.7

Date.	Temperature after injection.									Quantity injected.
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1897, June 16.	101.4	99.8	101.2	103.6	**105.8**	**105.8**	**105.**	**106.**	......	2.0 c. c.
Sept. 8.	102.	101.8	103.	**105.**	**105.**	**104.4**	**104.**	**104.2**	**104.**	2.0 c. c.
1898, Jan. 11.	101.6	101.6	102.2	102.4	**104.**	**104.**	103.6	102.8	102.8	2.0 c. c.
May 24.	101.2	101.2	101.6	102.2	102.6	102.4	102.6	102.4	102.6	2.0 c. c.
July 1.	.....	101.2	101.4	101.8	102.	102.4	103.8	**104.6**	103.2	2.0 c. c.
Aug. 30.	100.8	101	101.6	101.8	101.8	102.	......	103.	......	2.0 c. c.
Oct. 4.	.....	101.2	101.4	101.4	101.8	102.	103.	103.	102.8	2.0 c. c.
Nov. 1.	......	100.6	101.8	101.	101.4	102.	102.6	102.4	102.	2.0 c. c.
Dec. 3.	......	102.	102.8	102.6	102.8	101.6	103.	103.	102.8	2.0 c. c.
1899, Jan. 3.	.....	101.4	102.4	101.6	102.3	102.	103.4	103.	103.2	2.5 c. c.
Feb. 3.	......	102.	102.2	103.	103.2	103.	104.	103.2	103.2	3.0 c. c.
Mch. 29.	......	102.	102.	101.4	101.6	101.6	102.2	102.	101.8	3.0 c. c.

No. 29 had shown well marked reactions to the first three tuberculin tests. The fourth test was passed without reaction, and at the fifth, sixth and seventh tests there were indications of afternoon fever before, as well as following the injection; the eighth test was passed without change of temperature; at the ninth, tenth and eleventh tests there was a slight rise following the injection, but the twelfth test was passed without change. A calf was dropped between the eleventh and twelfth tests.

On autopsy tubercles were found in the portal and bronchial glands; several tubercles in each lung, and an abscess the size ot a hen's egg in the liver.

TABLE VIII—No. 30—VANITY LASS: Polled Angus cow, 8 years old at first test.

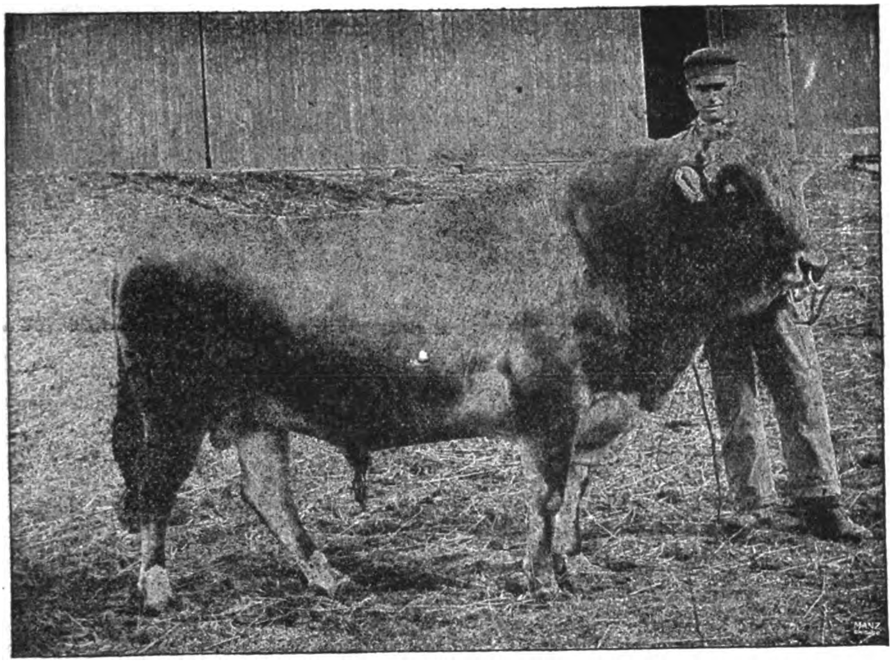
Date.	Live weight.	Temperature before injection.								
		8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average.
1897, June 15.	.....	.....	100.2	101.2	101.	101.8	101.8	101.6	101.6	101.3
Sept. 7.	.....	101.	100.6	101.	101.2	101.4	101.4	101.4	101.2	101.1
Dec. 28.	1100	102.	100.8	101.8	101.	......	102.	100.6	101.2	101.3
1898, May 23.	1321	101.8	101.4	101.6	102.	101.8	102.	102.	101.6	101.8
June 30.	1365	101.6	101.6	101.6	101.6	101.4	102.2	102.6	102.4	101.9
Aug. 29	.. ..	101.4	101.2	101.6	101.	101.4	102.6	103.	......	101.7
Oct. 3.	*1227	101.	101.6	101.2	101.2	102.	**103.**	**104.**	**103.**	102.1
Oct. 31.	1226	102.	101.8	101.2	102.	102.2	101.8	101.6	101.8	101.8
Dec. 2.	1281	103.8	103.6	102.6	101.8	101.6	101.2	100.8	100.4	102.
1899, Jan. 2.	1257	101.4	101.4	101.	101.8	101.6	101.6	100.8	101.	101.3
Feb. 2	1298	100.6	101.4	101.	101.4	101.	100.6	100.6	101 8	101.
Mch. 2.	1344	100.4	101.4	101.6	101.8	102.	102.	101.6	101.4	101.5
Mch. 28.	1336	101.4	101.6	101.	101.8	101.8	102.	101.2	101.4	101.5

	Temperature after injection.									Quantity injected.
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1897, June 16.	102.4	**104.8**	**106.**	**105.6**	**104.**	**104.**	**104.**	**104.**	......	2.0 c. c.
Sept. 8.	**105.6**	**105.2**	**105.**	**105.4**	**105.**	**104.**	103.8	103.	102.6	2.0 c. c.
Dec. 29.	101.6	102.8	**105.8**	**107.**	**104.8**	**102.6**	**104.6**	103.6	102.6	2.0 c. c.
1898, May 24.	101.2	101.6	102.	**105.**	**105.4**	**104.8**	**103.8**	**104.8**	103.6	2.0 c. c.
July 1.	.....	102.8	102.4	101.8	102.8	**104.2**	**104.4**	**104.2**	**104.4**	2.0 c. c.
Aug. 30.	101.4	100.8	101.4	101.4	102.2	102.8	.....	103.4	.....	2.0 c. c.
Oct. 4.	.....	101.4	101.4	101.2	101.8	102.	102.2	103.	103.4	2.0 c. c.
Nov. 1.	.....	103.8	103.6	**104.**	102.6	102.	102.	102.	101.8	2.0 c. c.
Dec. 8.	......	102.	101.8	102.2	101.4	103.2	**104.**	103.2	102.8	2.0 c. c.
1899, Jan. 3.	.. ..	101.2	102.	102.	102.4	102.	103.	103.4	103.6	2.5 c. c.
Feb. 3.	....	101.	101.2	101.4	102.4	**104.**	**105.**	**104.**	101.	3.0 c. c.
Mch. 3.	......	102.	101.2	101.	101.4	101.8	101.8	101.8	101.8	3.0 c. c.
Mch. 28.	.....	101.4	101.4	101.4	102.2	101.6	102.	101.4	101.	3.0 c. c.

* A calf was dropped Sept. 15, 1898.

In the case of No. 30 there were distinct reactions to the first five tests, followed by increase of temperature of afternoons, both before and after testing, for several months, then after testing only for several months longer. The last two tests were passed without change of temperature. The cow had increased steadily in weight up to the first of March, and was very fat when killed.

The autopsy revealed tubercles in the retro-pharyngeal, mesenteric and portal glands and several abscesses in the liver. One hind quarter of the udder was diseased.



TEENY'S FIRST

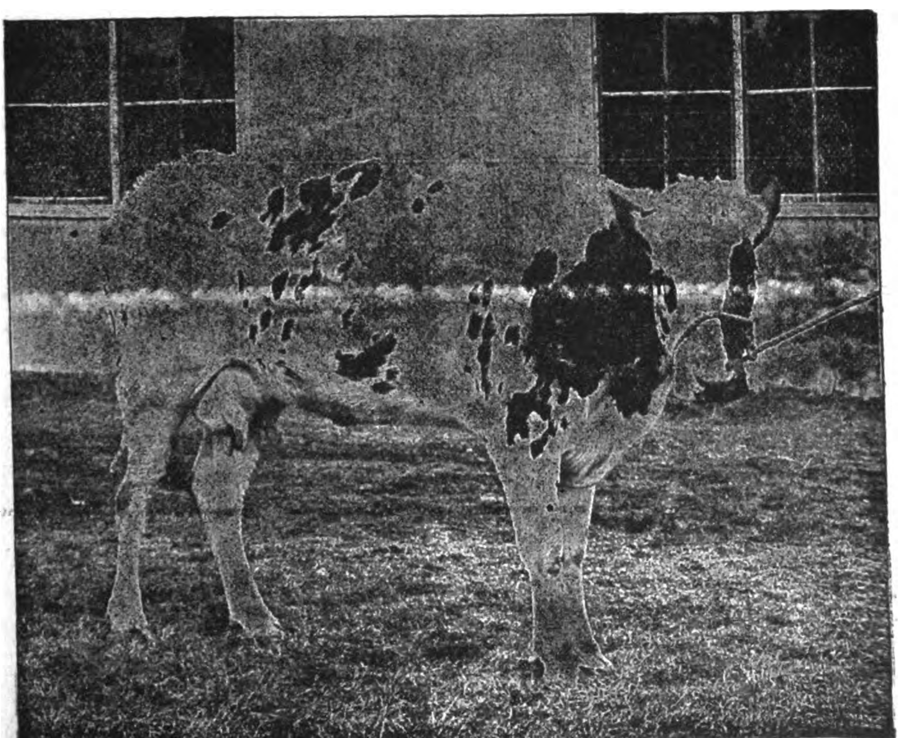


TABLE IX—No. 31—TEENY'S FIRST: Jersey bull, nearly 8 years old at first test.

Date.	Live weight.	Temperature before injection.								
		8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average.
1897, June 17.	......	.....	.....	......	101.	101.6	101.8	101.8	101.6	101.6
Sept. 7.	.....	100.	100.8	101.	101.	101.2	101.8	99.2	100.8	100.7
1898, June 30.	......	101.8	102.2	102.	101.8	102.2	102.6	102.4	102.	102.1
Aug. 29.	......	101.2	101.4	101.4	101.6	102.	**103.2**	**103.**	......	102.
Oct. 3.	......	101.	101.8	101.6	101.8	102.	102.	**104.8**	102.8	102.2
Oct. 31.	......	101.	100.8	101.	101.4	101.8	101.6	100.4	101.2	101.1
Dec. 2.	....	100.	100.8	101.4	101.6	101.6	101.6	99.8	100.	100.8
1899, Jan. 2.	1470	.....	101.	101.	101.6	101.2	101.6	101.	100.6	101.1
Feb. 2.	1499	99.2	101.6	101.8	101.4	101.	101.8	100.6	100.4	101.
Mch. 2.	1535	100.6	100.6	100.8	101.	102.4	101.8	101.6	101.2	101.2
Mch. 28.	1581	101.	101.	101.2	100.4	101.	101.8	101.4	101.	101.1

Date.	Temperature after injection.									Quantity injected.
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1897, June 18.	101.8	102.2	102.2	**106.**	**106.6**	**106.6**	**103.**	**104.8**	......	....
Sept. 8.	102.2	103.4	**104.4**	**106.**	**106.**	**106.**	**104.6**	103.	103.	....
1898, July 1.	......	102.2	102.2	**105.**	**104.2**	**104.6**	**104.**	103.4	102.2	....
Aug. 30.	101.4	100.4	102.2	102.2	102.4	102.8	......	103.	......	....
Oct. 4.	......	102.	102.4	103.	102.2	102.2	102.2	102.	102.4	....
Nov. 1.	......	100.6	101.	101.	101.	101.6	100.6	100.4	100.8	....
Dec. 3.	......	100.8	100.8	100.8	101.4	100.2	101.2	101.2	101.	....
1899, Jan. 3.	.....	101.2	101.	101.4	101.4	101.4	101.6	101.	101.	3.0 c. c.
Feb. 3.	......	101.	101.4	101.4	101.6	101.6	102.2	101.4	101.2	3.0 c. c.
Mch. 3.	......	101.2	100.4	101.	101.	101.4	102.	101.4	101.	3.0 c. c.
Mch. 29.	.....	100.8	100.6	101.2	100.6	100.8	100.4	100.8	101.	3.0 c. c.

The bull, No. 31, gave well marked reactions to the first three tests, with somewhat high temperatures at the next two, but for five months there had been no sign of abnormal temperature, and he was steadily increasing in weight. When killed he was very fat, his hair was sleek and bright, and he showed every external sign of perfect health.

On autopsy both retro-pharyngeal glands were found tubercular; the mesenteric glands were hard and congested; the portal glands were indurated, but without caseation or pus, and there was an old, encapsuled abscess in the liver.

TABLE X—No. 32—VANITY'S THIRD: Polled Angus heifer, 14 months old at first test.

Date.	Live weight.	Temperature before injection. 8 a.m.	10 a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Average.
1898, Jan. 10.	.....	102.	102.4	102.	102.2	101.8	102.	102.	102.	102.
June 30.	......	102.	102.	101.8	102.	102.6	**103.8**	**103.**	102.2	102.4
Aug. 29.	......	102.	101.8	102.	102.4	102.6	102.8	**103.2**	......	102.4
Oct. 3.	......	101.4	101.2	102.6	102.	102.	102.6	**103.6**	**103.4**	102.3
Oct. 21.	......	101.4	101.	101.2	103.	102.	**103.**	101.8	102.	101.9
Dec. 2.	......	102.	102.	102.	102.	101.6	101.6	101.6	101.	101.7
1899, Jan. 2.	782	101.2	101.6	101.6	102.	102.	102.	102.	101.8	101.8
Feb. 2.	812	101.4	101.6	101.8	101.8	100.4	101.2	101.4	101.4	101.4
Mch. 2.	833	101.4	101.6	101.8	101.2	102.	102.	101.6	101.2	101.6
Mch. 28.	857	101.8	101.6	101.8	101.6	101.8	102.	101.8	101.6	101.7

	Temperature after injection. 6 a.m.	8 a.m.	10 a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10 p.m.	Quantity injected.
1898, Jan. 11.	102.4	102.8	103.	103.6	103.6	103.6	103.	102.4	102.2	....
July 1.	......	102.2	102.2	101.8	102.2	103.	**104.**	**104.**	103.	....
Aug. 30.	102.4	102.4	102.2	102.	102.	103.4	......	102.8	......	....
Oct. 4.	......	101.8	101.6	101.6	101.8	102.	103.	103.	103.2	....
Nov. 1.	.....	101.4	101.4	101.2	101.4	101.4	102.	102.4	102.4	....
Dec. 3.	......	102.2	101.8	101.6	102.	102.	102.	101.6	101.4	....
1899, Jan. 3.	....	102.2	102.	102.2	102.2	102.	102.6	103.	102.6	2.0 c.c.
Feb. 3.	......	102.	102.	102.2	102.2	102.8	102.	102.2	102.	2.0 c.c.
Mch. 3.	...	101.	101.	102.	102.	101.8	102.4	102.	102.	2.0 c.c.
Mch. 29.	......	102.	102.	101.	101.4	102.	102.	101.8	101.6	2.8 c.c.

No. 32, a daughter of Vanity Lass, had shown abnormal afternoon temperatures on several occasions, but never a well marked, tuberculin reaction.

The mesenteric glands were enlarged and indurated, but no other abnormal condition was observed. The animal was in good flesh and apparently in perfect health. She was condemned chiefly on the test of July 1, 1898, but it would seem that in handling young animals a larger margin should be allowed than was done in this case.


VANITY'S THIRD


NELLY'S THIRD

TABLE XI — No. 33 — NELLY'S THIRD: Red Polled heifer, 2 years old at first test.

Date.	Live weight.	Temperature before injection.								
		8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average.
1898, Sept. 9.	......	101.2	101.2	101.6	101.8	101.8	102.	102.6	102.6	101.8
Oct. 31.	......	100.6	102.	102.	102.	101.4	102.	102.2	101.6	101.7
Dec. 2.	.....	101.8	102.	101.4	101.6	101.2	101.2	101.4	102.6	101.6
1899, Jan. 2.	907	101.8	.....	101.6	101.6	101.6	102.2	101.2	101.4	101.6
Feb. 2.	951	101.6	101.6	101.6	101.4	101.6	102.	101.4	101.	101.5
Mch. 2.	985	101.8	102.	102.	102.	101.6	101.8	101.6	101.6	101.8
Mch. 28.	1003	100.8	101.6	101.2	101.	101.8	102.2	101.6	101.2	101.4

	Temperature after injection.									Quantity injected.
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1898, Sept. 10.	......	**105.**	**105.6**	**106.**	**106.8**	**106.8**	......	......	......	....
Nov. 1.	.....	102.8	**104.4**	**105.**	**105.**	**104.4**	**105.**	**104.**	103.8	....
Dec. 3.	......	103.	103.6	103.6	103.8	103.4	**104.**	103.	103.	....
1899, Jan. 3.	......	101.4	102.4	102.	102.	102.2	102.4	102	102.	2.0 c. c.
Feb. 3.	......	101.8	101.8	102.	102.	102.4	102.6	102.	101.8	2.0 c. c.
Mch. 2.	......	101.8	102.	102.	101.8	101.8	102.6	102.	101.8	2.0 c. c.
Mch. 29.	......	101.	101.4	101.	101.	100.6	101.	101.2	101.	2.0 c. c.

No. 33 had given two well marked reactions to the tuberculin test, with a third, somewhat indecisive, followed by four negative tests.

Tubercles were found in the retro-pharyngeal glands. The heifer was in splendid condition, and by external appearances in perfect health when killed.

TABLE XII — No. 34 — GRACE MAHOMET: Holstein heifer, 1 year old at first test.

Date.	Live weight.	Temperature before injection.								
		8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average.
1898, Sept. 12.	....	102.	101.8	101.6	102.	102.	102.4	**103.**	**103.6**	102.3
1899, Jan. 2.	455	102.4	102.8	102.7	103.8	101.6	**103.**	102.4	**103.6**	102.8
Mch. 2.	603	102.	102.6	102.	102.	102.8	102.4	102.6	102.	102.3
Mch. 28.	669	102.6	102.	101.8	101.	101.2	102.2	101.8	102.2	101.8

	Temperature after injection.									Quantity injected.
	6 a.m.	7 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1898, Sept. 13.	......	101.6	101.6	102.6	102.4	103.	**104.4**	**105 2**	**105.2**	....
1899, Jan. 3.	......	102.4	103.	103.2	103.2	102.	103.6	103.8	103.6	1.2 c. c.
Mch. 3.	......	102.	101.8	101.6	101.8	102.	103.2	101.4	101.2	1.5 c. c.
Mch. 29.	......	102.	102.8	101.	101.6	101.8	102.8	100.8	101.8	1.8 c. c.

No. 34 had shown a distinct reaction in September, 1898, with abnormal temperatures before and after the test of January following, but had passed two later tests without reaction.

The portal glands were found enlarged and indurated, but without caseation or pus. On the small intestines there were found great numbers of small, pea-sized, caseated foci, containing green-colored, caseous masses, probably of parasitic origin. There had been some diarrhœa, but the animal was still in good condition.

TABLE XIII—No. 35—VIOLA'S FOURTH: Red Polled heifer, 17 months old at first test.

Date.	Live weight.	Temperature before injection.								
		8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average.
1898, Sept. 9.	....	102.4	101.4	102.	102.6	**103.**	**103.4**	**103.**	**103.4**	102.6
1899, Jan. 2.	694	101.6	101.6	101.6	102.2	102.4	101.8	101.2	101.	101.7
Mch. 2.	802	101.4	101.8	101.8	101.6	102.6	102.4	102.	101.4	101.9
Mch. 28.	823	102.	101.8	101.4	101.2	102.	101.8	101.4	101.	101.6
	Temperature after injection.									Quantity injected.
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1898, Sept. 10.	......	102.2	102.	102.	102.4	102.6	**104.**	**104.4**	.....	....
1899, Jan. 3.	......	101.6	101.6	102.	102.4	101.8	101.8	102.	102.2	1.5 c. c.
Mch. 3.	......	101.4	101.4	100.8	101.	101.8	101.8	101.6	101.8	1.5 c. c.
Mch. 29.	......	101.4	101.8	101.4	101.6	100.8	101.6	101.6	101.6	1.5 c. c.

No. 35 was condemned because of the rise of temperature at the first test. It will be observed that the temperature was slightly above the normal on the afternoon preceding the test, and that the total elevation, following the injection of tuberculin, was less than two degrees above the average temperature of the previous day.

The autopsy revealed no indication of tubercular disease, but the intestines were slightly infested with the nodules found on several of the younger cattle killed in this test

TABLE XIV—NO. 36—FANNY DAW'S SECOND: Holstein cow, 2 years old at first test.

Date.	Live weight.	Temperature before injection.								
		8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average.
1897, Dec. 22.	.....	102.	102.	102.	102	101.6	101.	101.6	101.2	101.7
1898, Sept. 9.	......	102.2	101.6	102.4	101.8	**104.**	**103.**	**103.2**	**103.4**	102.7
1899, Jan. 2.	1042	101.4	101.4	102.2	101.8	100.	101.	101.2	101.8	101.3
Mch. 2.	946	101.2	102.	103.	102.4	**103.2**	101.6	101.4	101.6	102.
Mch. 28.	980	100.8	101.8	101.2	101.8	102.	102.2	101.8	102.	101.7

Date.	Temperature after injection.									Quantity injected.
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1897, Dec. 23.	101.8	101.4	102.4	101.8	101.8	100.8	101.	100.8	101.6	....
1898, Sept. 10.	......	102.4	102.4	102.	104.	103.	**104.**	103.	......	....
1899, Jan. 3.	......	102.2	102.2	102.4	103.	103.2	102.2	102.	102.	2.0 c. c.
Mch. 3.	......	101.6	101.6	101.	102.	102.2	102.6	102.	102.2	2.0 c. c.
Mch. 29.	......	102.8	102.4	101.6	102.4	102.4	102.	101.8	102.	2.0 c. c.

In the case of No. 36, as in that of No. 35, there had been a suspicious rise of temperature in the September test, following a slight rise the previous afternoon, the total elevation reaching only to 104 degrees.

On autopsy the same conditions were found as in the case of Viola's Fourth—an entire absence of tubercular deposits, but a few nodules on the intestines.

TABLE XV—No. 37—INFIRMARY CALF: Grade Red Polled heifer, 2 weeks old at first test.

Date.	Live weight.	Temperatnre before injection.								
		8 a.m,	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average.
1898, Sept. 9.	......	102.6	102.	102.	102.2	102.	102.4	102.	101.8	102.1
Oct. 31.	......	101.4	102.4	102.	103.	103.	103.	104.	103.6	102.8
1899, Jan. 2.	357	102.4	102.8	102.8	103.	103.	103.	102.6	103.	102.8
Mch. 28.	516	101.8	101.8	102.	102.	102.2	102.6	101.8	102.2	102.

Date.	Temperature after injection.									Quantity injected.
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1898, Sept. 10.	......	102.4	102.2	102.6	102.8	102.6	102.6	103.	.....	....
Nov. 1.	......	100.2	102.	102.2	101.8	102.8	102.4	102.4	102.6	....
1899, Jan. 3.	......	102.6	102.6	102.8	102.6	103.6	103.4	103.	103.	1.2 c. c.
Mch. 29.	......	102.6	101.8	102.4	102.	102.	102.	102.	102.	1.4 c. c.

No. 37 had been purchased for the purpose of feeding it the milk of the tuberculous cows included in this test. It was not related to any of the cattle in the Station herd. The tuberculin record shows no reaction at any time to the test, and the autopsy revealed no indication of any disease whatever. It will be observed that the calf was only two weeks old at the September test, and that it was not infested with the intestinal nodules found in the older animals.

TABLE XVI—No. 38—PETER DAW: Holstein bull, 3 months old at first test.

Date.	Live weight.	Temperature before injection.								
		8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	Average.
1898, Sept. 12.	322	102.2	101.4	101.2	102.4	102.6	103.4	102.6	102.8	102.3
1899, Jan. 2.	......	102.2	102.6	102.6	103.4	101.6	102.4	102.	102.	102.3
Mch. 28.	533	103.6	103.2	101.6	102.	102	102.	102.8	102.	102.4

	Temperature after injection.									Quantity injected.
	6 a.m.	8 a.m.	10a.m.	12 m.	2 p.m.	4 p.m.	6 p.m.	8 p.m.	10p.m.	
1898, Sept. 13.	......	102.	102.6	103.4	**105.**	104.	103.8	104.	102.6	....
1899, Jan. 3.	......	**105.4**	**106.4**	**106.6**	**107.**	**107.**	**106.2**	**106.**	**105.6**	1.2 c. c.
Mch. 29.	......	104.	104.	102.8	102.8	103.	103.6	103.8	103.8	1.5 c. c.

Peter Daw had given two distinct reactions to the tuberculin test, and the autopsy showed enlarged and indurated mesenteric glands, with several small nodules in the intestines, filled with greenish, caseous matter, such as were observed in several of the younger animals.

As pertinent to the afternoon fever, previous to the tuberculin injection, which has been observed in several of the cattle included in this test, I give the following averages of 100 observations, made on 38 non-reacting cattle, of all ages, between June, 1897, and April, 1899, the cattle being taken without other selection than their failure to react to the tuberculin test.

8 A. M.	10 A. M.	12 M.	2 P. M.	4 P. M.	6 P. M.	8 P. M.	10 P. M.
102.07	102.06	101.92	102.01	101.89	102.01	101.95	101.75

It will be observed that these average temperatures show no indication of afternoon elevation. The occurrence, however, of high temperatures in some of our animals which were found to be only in the first stages of tuberculosis, or entirely free from tubercular deposits, shows that such temperatures cannot always be taken as indicating advanced consumption.

The nodular deposits on the intestines, found in several of these younger cattle, are not unusual. When their contents are greenish in color, as in these cases, parasitism is indicated, tubercular deposits being yellowish.

The tuberculin records and post mortem notes of the 12 animals slaughtered in the test of April 11 (No.'s 27 to 38, inclusive) were submitted to Dr. D. E. Salmon, Chief of the Bureau of Animal Industry, who directed that the carcasses of No.'s 28, 29, 30 and 31 should be destroyed, and authorized the sale for food of the remainder. On four of these last, it will be observed, no indication of tubercular disease had been found, and on the other four the lesions were limited to the enlargement or induration of a single gland, or set of glands, without caseation or pus.

CONCLUSIONS.

In the 38 cases herein reported there have been but two, No's 15 and 27, in which the tuberculin diagnosis, whether positive or negative, has not been confirmed by post mortem examination. In the case of No. 15 there was ample time for infection between the test and the autopsy, and in that of No. 27 there is the possibility that recovery had taken place.

In a number of cases, however, especially in those in which the test was most frequently repeated, animals after responding to the test have ceased to react to later tests, and yet have been found tuberculous when killed. In some of these cases there has been room to believe that the disease was in abeyance, or even that a recovery had been made, or was in progress; but it would not be safe to assume that the non-reaction to the test of an animal which has previously given one or more distinct reactions is, in itself, evidence of recovery.

EFFECT OF THE TUBERCULIN TEST ON THE HEALTH OF THE ANIMAL.

It is, of course, impossible to tell the exact condition of these cattle when they were first injected with tuberculin; but at the time when the draft was made for the slaughter of June 8, 1898, the seven animals which were reserved were, as well as we could determine, as far advanced with the disease as the reacting animals which were killed. Six of these reserves had reacted to the tuberculin test as distinctly and as often as those which were killed, and they were in no better condition, as judged by visual inspection, all being apparently in perfect health.

One of these reserves soon died with advanced tuberculosis, but the autopsies on those which were killed ten months later indicate, if any difference, a less advanced, rather than a farther advanced stage of the disease than that found in those killed at the earlier date, while in the case of the younger animals, added to this reserve herd as the result of later tests, the disease had not progressed in six months beyond the enlargement and induration of one or two glands, and all this in the face of tuberculin injections, repeated every four to six weeks.

The bull, No. 31, which had first reacted nearly two years previous to the autopsy, had passed the last six tests with no elevation of temperature whatever, and the lesions found were limited to a few glands and an old, partly healed abscess in the liver. In the case of the older cows the later tests were usually followed by slight elevations of temperature, although not sufficient to be taken as indicating tubercular disease had they not been preceded by more decided reactions. While the disease showed evidences of generalization in these cases, there was no sign of rapid progress, and, taken as a whole, the tests cannot be interpreted as supporting the theory that the tuberculin test will arouse dormant cases of tuberculosis and start the disease into a more active form.

On the other hand, these experiments show that the tuberculin test indicates the presence of tuberculosis at such an early stage as to give ample time to fatten the animal before the disease has progressed so far as to affect the meat.

DISPOSAL OF THE MEAT OF TUBERCULOUS ANIMALS.

The question whether the carcasses of the animals slaughtered in the incipient stages of tuberculosis should be used for food is one of far reaching importance. If this disease were attended from the first with high fever and other symptoms of general sickness, there could be no question on this point; but the fact is that, in its ordinary course, there is no fever and not the slightest sign of functional derangement until either the liver or the lungs, usually both, have become deeply involved, and this, as shown by the tests herein reported, may not occur for two years or more after the first infection.

During this period the disease is limited to organs which are not ordinarily used for food, and if the portions of the carcass which are so used were accidentally infected by the knife of the butcher such infection would be limited to the outside of the meat, where the germs would most surely be destroyed by cooking, while those who eat raw meat take far greater risks than that from tuberculosis.

In view of these facts the governments of Germany, France and Denmark and our own Bureau of Animal Industry authorize the sale for food of carcasses of animals in which tuberculosis, though present, has not become generalized, the only exception to the unobstructed sale of such meat being in the case of Germany, where it is required that it must be first boiled and then sold as coming from tuberculous cattle.

Our experiments have shown that an animal may be capable of several years of usefulness after it has become infected with tuberculosis, but that it is liable at any time to break down; while we do not know when it may first become a disseminator of the seeds of the disease; possibly from the first infection, more likely, in most cases, not until after the disease has become more generalized.

Under these circumstances the average cattle owner will be much more reluctant to consent to the slaughter of young cattle because of reaction to the tuberculin test if all which show the infection are to be destroyed, no matter how slight the lesions, than if such as are in perfect health, except the incipient infection of one or two minor glands, may be sold for meat. Under the first named conditions there will be the constant temptation to try to keep the animal a little longer, in the hope that it may recover, or that a little more produce may be realized from it, or else to smuggle it into the market, than if it can be sold openly for food, subject only to the conditions of an inspection which certainly

seems to conform to all reasonable hygienic requirements without unnecessary sacrifice of property.

HOW FREQUENTLY SHOULD THE TUBERCULIN TEST BE REPEATED.

Our tests show that the tuberculin test may be repeated as often as once a month, not only without injury to the animal but with a suggestion of curative effect; but when the object is to ascertain whether tuberculosis is present the interval between injections should be longer than a month. Considering all points it would seem that once in six months would be sufficiently often for the testing of a herd from which the disease is being extirpated, and that once a year would be often enough for an ordinary dairy or breeding herd in which no tuberculosis has appeared.

Experiments touching on the curative effect of tuberculin are reported in the annual reports of the Pennsylvania State College Experiment Station for 1894 (p. 110); of the New Jersey Agricultural College Experiment Station for 1895 (p. 187), and 1897 (p. 224); of the Canada Experimental Farms for 1896 (p. 89); of the Delaware College Agricultural Experiment Station for 1898 (p. 14); of the Maine Agricultural Experiment Station for 1897, and in Bulletin 29 of the Iowa Agricultural College Experiment Station, but none of these can be considered decisive.

It is well established that the reactions become less and less distinct in frequent repetitions of the tuberculin test, a fact that opens the way for serious abuse of this test.

It should be stated that the animals included in our last slaughter test had been fed for fattening for several months before the slaughter, a fact which may have had some influence in retarding the progress of the disease.

TUBERCULOSIS IN SWINE.

Out of a litter of seven Berkshire pigs four were selected in the fall of 1898, separated into two lots of two pigs each and fed on the milk of the cows of the reserve herd; the milk being pasteurized for one lot, but fed untreated to the other. Other food was added and the pigs grew well and fattened. As they came from a sow that had been on the farm several years and had produced several litters of apparently healthy pigs, they were not tested with tuberculin at the beginning of this experiment; but a few days before the slaughter test of April 11 they were subjected to the test and all gave the characteristic reaction. When slaughtered, all were found to be in a condition of generalized tuberculosis; tubercular deposits being found along the windpipe, in the bronchial, mesenteric and portal glands and in the liver. One of the livers is shown on page 325. Later, the other three pigs, which had no milk, were killed, and these were found to be in practically the same condition as those which had been

under experiment. To external appearance the pigs were all in perfect health.

A few days after the slaughter the sow died in pig-bed. She was carefully examined, and while a very few, small, tubercular deposits were found in the liver, there was nothing that could account for the condition of the pigs until the udder was opened; but in that was a solid, calcified mass of tubercle, nearly as large as a hen's egg. This mass was covered with a fleshy envelope, and was apparently in a dormant condition, there being no pus. Apparently the sow had been sowing the seeds of infection in her progeny while suffering but little inconvenience from the disease herself.

The investigations of the Bureau of Animal Industry indicate that swine are quite as subject to tuberculosis as cattle, and that the meat of tuberculous swine is even more dangerous than that of tuberculous cattle, because the disease, as a rule, becomes generalized more rapidly in swine than in cattle. As an illustration, the disease was farther advanced in the case of the one-year-old pigs above referred to than in that of cattle which had reacted to the tuberuclin test nearly two years before.

THE PREVALENCE OF BOVINE TUBERCULOSIS.

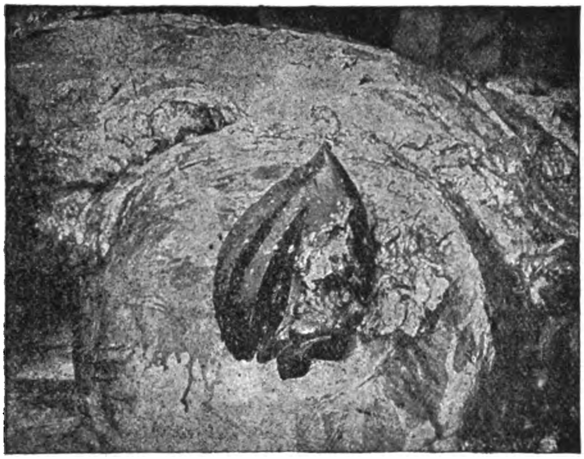
Before the discovery of the tuberculin test it was impossible to make even an approximate estimate of the proportion of cattle affected with tuberculosis; but the work which has been done since that discovery shows that the disease is far more prevalent than had been suspected.

The most thoroughgoing investigations on this point which have been carried out in any country are those made in Denmark, under direction of Dr. B. Bang, of Copenhagen. Up to the end of October, 1895, Dr. Bang had reported the testing with tuberculin of 53,200 cattle in 1,972 herds, by 210 Veterinarians. Of this number, 26,665. or 38.7 percent reacted to the test. In 107 of these herds, containing more than 50 cattle each, the percentage of reacting animals was 59.8; while in herds of less than 50 cattle it was 32.2 percent. 309 herds, containing less than 50 each, were found free from the disease. In other words, 5 herds out of every 6 were infected, and in infected herds 2 animals out of 5, in the average, were diseased.[1]

In 1897 the British Royal Commission on Tuberculosis visited Denmark and found that up to that time nearly 150,000 cattle had been tested under Dr. Bang's direction, with results that were considered very satisfactory by the owners and the authorities. This same Commission visited Belgium, and found that 22,000 cattle had been tested, and Prof. J. McFadyean, in a summary of the report of the Royal Commission[2] estimates

[1] Report in Bulletin 41, Massachusetts (Hatch) Experiment Station.

[2] Journal of the Royal Agricultural Society of England, June, 1898, pp. 323–344.



ONE OF THE HOG LIVERS, SPECKED WITH TUBERCULOUS ABSCESSES

PATTI'S LUNGS. TUBERCULAR MASS AT *a*, FULL OF PUS

that from 30 to 40 percent of the breeding cattle of Great Britain are affected with the disease. The same Commission reports statistics from 29 towns in Saxony where a rigid inspection of slaughtered cattle is maintained, showing that 27.5 percent of the cattle slaughtered in 1895 were tuberculous.

In 1894 a law was enacted in Massachusetts, providing for a general inspection of the cattle of the state. Under this law 21,390 cattle were subjected to the test during the four years, 1894-'97, of which number 11,633 were condemned.[3] The total enumeration of cattle in the state averaged 210,000 for the four years, of which 175,000 were cows. Asuming an annual change of 20 percent in the number of cattle, there may have been a total of 370,000 under inspection during the four years, of which number about 3 percent were found tuberculous. Experience has shown, however, that mere physical inspection does not ordinarily detect half the cases of actual tuberculosis. On this point Prof. Nocard, previously quoted, shows that the number of tuberculous cattle in Denmark ran from 17 percent in 1893, under physical examination, to 40 percent in 1894 under the tuberculin test.

In 1894 the New York State Board of Health tested 27,000 cattle, chiefly within the region supplying New York city with milk, and caused the slaughtering of 845 as tuberculous. This is about 3 percent of the number examined. In 1895 and 1896 this work was placed in charge of a special tuberculosis commission, which reports to the State Board of Health, showing 3,813 inspections for the two years, with 758 reactions, or nearly 20 percent. It appears that the work of this commission was limited to herds in which tuberculosis was suspected; whereas that of the State Board of Health was more general. In 1895 and 1896 the Vermont State Board of Agriculture, acting as cattle commissioners under a special law, tested 14,155 cattle, of which 924, or 4.53 percent, were killed as tuberculous. This work was done at the request of owners of cattle, being commenced in herds where there was some cause for suspecting disease and extended as far as practicable to other herds.[4]

New Jersey established a tuberculous commission in 1895. From the report of this commission for 1897 it appears that they tested with tuberculin 865 cattle during that year, of which number 134, or 15 percent were condemned. It is probable that only suspected herds were examined, but the report at hand is indefinite on this point.[5]

In Connecticut, from January 1st until July 15th, 1896, 2,032 animals

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[3] Am. Agriculturist, May 21, 1898.

[4] Report of the Vermont State Board of Agriculture, acting as Cattle Commissioners. 1896.

[5] Report N. J. State Board of Agriculture, 1887-8, p. 154.

were examined by a state commission, and 349, or 17 percent, were found to be tuberculous.[6]

In Rhode Island the State Board of Agriculture is charged with the suppression of tuberculosis in cattle, sheep and swine, but has not been authorized to use tuberculin as a diagnostic, except at the expense of the owner of the animals tested, and therefore has depended upon physical examination. During the four years, 1894 to 1897 inclusive, 2,043 cattle were killed as tuberculous in a state enumerating but 36,000 cattle in January, 1898.[7] In view of the practical certainty that less than half the actual number of tuberculous animals would be found by this method, these statistics indicate a serious prevalence of this disease.

In Pennsylvania the Live Stock Sanitary Board is charged with the examination of herds of cattle in which tuberculosis is suspected, and up to the end of 1897 this board had tested with tuberculin about 16,000 animals, of which 2,500, or more than 15 percent, had reacted.[8]

In a single herd of cattle in Pennsylvania, that of the State Hospital for the Insane, at Norristown, 166 cattle were tested with tuberculin in 1894, and 118, or 70 percent were found to be tuberculous. Attention had been called to this herd by the frequent deaths among the cattle which were supplying the institution with milk and meat.[9]

Comparatively few of the states have as yet provided for systematic inspection of cattle for tuberculosis, but considerable work has been done by state veterinarians and experiment stations in demonstrating the wide prevalence of the disease.

At the Arkansas Experiment Station two herds of cattle were tested in 1895, one of which was found to be free from the disease, but in the other herd of eighteen animals there were four cases of reaction.[10]

The Delaware Experiment Station tested 951 animals during the years 1892-5, revealing 186 cases of tuberculosis, or nearly 20 percent. In discussing these results, however, the Director of the Station points out that the number of cows tested is not yet sufficient to afford an index to the actual prevalence of bovine tuberculosis in the state.[11]

From December, 1893, to December, 1896, the Indiana Experiment Station tested 312 cattle, of which number 7 were condemned as tuberculous.[12]

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[6] Abstract in Report of Maine Commissioners on Contagious Diseases of Animals, 1897, p. 46.

[7] Reports of R. I. State Board of Agriculture, 1894–97.

[8] Pennsylvania Department of Agriculture, Bulletin No. 84, p. 120.

[9] Special Report on Bovine Tuberculosis: State Hospital for the Insane, Norristown, Pa.

[10] Eighth Annual Report, p. 147.

[11] Seventh Annual Report, p. 53.

[12] Bulletin 63.

The Iowa Experiment Station reported in 1895 the testing of 873 cattle in 50 herds, with 122 reactions, or 14 percent.[13]

At the Kansas Experiment Station, in October, 1897, 80 cattle were tested with tuberculin and 15 condemned, the tuberculin test being confirmed by slaughter and post-mortem examination.[14]

The Louisiana Experiment Station tested 22 cattle in 1896, and found 6 tuberculous.[15]

The Veterinarian of the Michigan Experiment Station reports 698 tests in his state up to January, 1898, with 77 reactions, or 12 percent.[16]

In 1896 the Veterinarian of the Minnesota Experiment Station reported 3,430 tests of cattle for tuberculosis, made by himself as the City Veterinarian of St. Paul and Minneapolis, with 380 reactions, or 11.1 percent.[17]

At the Ohio Experiment Station 132 cattle have been tested with tuberculin, and 41 have reacted to the test.

At the Ontario Experimental Farms, including the central farm at Ottawa and three branch farms, located at Manitoba, British Columbia and Northwest Territory, a total of 314 cattle were tested from 1894 to 1897 inclusive, and 98 reacted to the test, or 31 percent. In 1894 the disease was found at all the farms. At the second test, in 1897, only two cases were found on one of the branch farms, but the central farm had been thoroughly reinfected.[18]

The Ontario Agricultural College reports in 1897, 662 tests, made in various parts of the province, with 160 reactions or 24 percent.[19]

During the winter of 1893-4 the herd of 30 cows belonging to the Wisconsin Experiment Station was found to be diseased. The tuberculin test condemned 28 animals and the test was confirmed by autopsy.[20]

These cases are abundantly sufficient to show the prevalence of the disease. They do not, of course, give any accurate information as to the actual percentage of diseased animals in the country at large, since, in most cases, they show the percentage in suspected herds only, and the figures are generally larger than would be indicated by a test of all the cattle in the country.

Government inspectors now stand in all the great stockyards and slaughterhouses where cattle are killed for export, charged with the duty of preventing the slaughter for meat of all animals which are visibly diseased, and of condemning the carcasses of such cases as may have escaped detection before slaughter.

[13] Bulletin 29, p. 253.
[14] Bulletin 79.
[15] Bulletin 43.
[16] Bulletin 133, p. 11.
[17] Bulletin 51.
[18] Reports of Experimental Farms, 1894, p. 58; 1896, p. 89; 1897, p. 70.
[19] Report for 1897, p. 147.
[20] Annual Report, 1894, p. 2.

Dr. D. E. Salmon, Chief of the Bureau of Animal Industry, which is charged with this inspection, replies as follows to a request for information as to the number of tuberculous animals found by these inspectors:

> "The number of post-mortems held by this Department at abattoirs throughout the country for the fiscal year ending June 30, 1898, was 4,418,730; 69,000 were condemned by inspectors and 3,163 were found tuberculous. I have not given the antemortem inspections for the reason that all animals rejected in yards are not slaughtered. 14,217 were rejected in yards and 2,892 slaughtered, 310 being found tuberculous."

These statistics would indicate that somewhat less than one animal in every thousand sent to the great abattoirs is condemned for tuberculosis, under the rules of the Bureau of Animal Industry, which only call for condemnation of the carcasses when the disease is found to be generalized. If all the slightly diseased animals were included the number would probably reach two or three per thousand.

The facts given show that bovine tuberculosis is to be found in all countries where cattle are kept, and this revelation seems at first to give a negative answer to the question: — "Is it possible to free our herds from this disease?" But before accepting this answer as final we must remember that the same investigations which have shown the general prevalence of the disease have also shown that in every country there are herds of cattle that are entirely free from it, just as there are human families similarly free in every neighborhood. Even in Denmark, where the average infection is so great that two-fifths of all the cattle tested reacted to the test, yet about one-sixth of all the *herds* tested were entirely free from the disease. The area of Denmark is 15,284 square miles, or approximately three-eighths that of Ohio; but its cattle population was given in 1893 as 1,696,000, as against 1,339,000 enumerated in Ohio the same year, showing that there are about three times as many cattle to the square mile in Denmark as in Ohio. Says Dr. James Law:

> "In infected breeding and dairy herds in New York, consisting largely of mature cows, I have found a maximum of 98 per cent and a minimum of 5 per cent. Again, in healthy country districts I have found hundreds of cows in adjoining herds without a trace of tuberculosis among them."[n]

These facts show that it is possible to keep herds of cattle free from this disease, even when surrounded by infected herds; but if it be possible to keep part of our cattle free, under such conditions, it is possible to keep all free.

THE PREVALENCE OF BOVINE TUBERCULOSIS IN OHIO.

In order to obtain information regarding the prevalence in Ohio of bovine tuberculosis, and also to ascertain what action the municipalities of the state have taken on the subject of meat and milk inspection,

[n] Bulletin 65, Agricultural Experiment Station of Cornell University, p. 107.

the following circular was sent out at the beginning of the year to the health officers and veterinarians of the state:

INQUIRIES RESPECTING MILK AND MEAT SUPPRY OF CITIES.

To Health Officers and Veterinarians:

We solicit your kind assistance in obtaining the information called for in the following inquiries. Please fill out the blanks with at least a yes or no — any further information which you may have time to add will be highly appreciated — and return with your name and address to,

Experiment Station,
Wooster, Ohio.

1. Are you aware of the discovery of any cases of tuberculosis among the cattle supplying your city with milk?
2. Has the tuberculin test been applied to any of the cattle furnishing your milk supply?
3. Has your city taken any action looking towards the inspection of the dairies supplying it with milk?
4. Has there been any attempt at meat inspection in your city?
5. Is any investigation being conducted in your city, either by the city or by private enterprise, having for its object to learn whether there is any connection between bovine and human tubercular disease?"

One hundred replies to this circular have been received from points within the state, 15 of which answered the first question in the affirmative, and several others, while replying in the negative to the question as put, reported the discovery of the disease on farms in the vicinity. No reply of any sort has been received from Cincinnati, but those from all but one of the other cities of the state, having a population of 25,000 or over, indicate that the disease has been found, either in some of the herds supplying the cities with milk or in the near vicinity. We quote as follows:

1. "About four years ago the owner of a herd of pure bred cattle came to me for medicine for one of his cows, which was losing flesh and had a bad cough. The cow died two or three months later, and I found on examination a bad case of tuberculosis. A bout a year later he sold a cow to a farmer near town who milked her through the summer and the following winter fed her for beef. When slaughtered she was found to be diseased, and I was called to examine the carcass. I found the lungs, liver and spleen full of tuberculosis and condemned the meat as unfit for food. In the fall of 1896 a farmer bought a bull calf out of this herd. The calf had run with the cow all summer and looked well, but after it had been weaned for some time it began to get poor and finally the owner killed it as worthless. Two other animals from the same herd have proven diseased but are still living, and while no opportunity has been given to test the herd with tuberculin the indications are that nearly the whole herd is affected with tuberculosis. There has been no bad effect from the use of the milk of this herd, so far as we can see; the family seem stout and hearty, yet infection may have taken place long before this, only to prove fatal in the future."

3. "I believe cases do exist among cattle supplying city milk. I have found cattle in the city which I believed to be affected and I think the tuberculin test should be applied." (Cleveland.)

4. The following letter comes from one of the principal grazing counties of the state — a county in which there is no large town:

"I have been examining animals in this and adjoining counties for ten years, and I found a herd of 20 a few days ago that was sound by the test. This herd is the first sound one in that time. My tests show that at least 30 per cent of the milk and meat supply, is more or less affected with tuberculosis. I find calves at 4 to 6 months old, fed from tuberculous cows, badly affected. I have found 33 cases on different farms in cattle alone this last year. Post-mortems showed 30 of this number affected in the lungs and air passages."

8. "There have been several cases of tuberculosis in our county, but the animals were destroyed on discovery of the disease."

10. "I think we have some tuberculosis in this county, but not nearly so much as in some other portions of the state."

32. "About two years ago the health officer made a visit to the different dairy farms and found a few very bad cases in cows that were furnishing milk to the city. In one case a cow was found that weighed scarcely 600 pounds, could hardly stand, had well marked lung lesions, temperature almost 104, and yet the lady owner declared that her milk was excellent and that her baby was doing well on it and could not get along without it."

42. "I have had three cases in my practice, some distance from town. I held post-mortem in two of them which confirmed my diagnosis. I think there is more tuberculosis in cattle around here than the people have any idea of. I have seen a number of cases that looked very suspicious to me, and their milk is being consumed daily."

53. "I have seen a few cows which I have looked upon with suspicion, but I have never used the tuberculin test to confirm my suspicions."

56. "In ten years I have seen 4 or 5 cases of tuberculosis in good Jersey cows and verified my diagnosis by autopsies. These cases were widely separated and in the country. I have been watchful but have seen no person nor animal contaminated from these few cows being thus diseased. I have not seen a case for five years."

66. "Yes. I am not able to say what percent."

67. "A few cases have been discovered but there are probably many more." (66 and 67 from the same city.)

70. "Yes, I know of a number of cases in this vicinity." (Columbus.)

72. "I have met with several cows owned by farmers, which showed symptoms of tuberculosis, but none in our city dairies."

76. "No, but I have just destroyed a fine Jersey bull that has suffered with dysentery for several months. I diagnosed tubercular dysentery and post-mortem revealed the tubercular nodules, well formed and in different stages, in the bowels and also in the lungs."

77. "Last fall I made an autopsy on a cow that died with the disease and am awaiting developments."

79. "One cow in the vicinity afflicted with tuberculosis was promptly killed some two years ago." (In reply to the second question this correspondent writes): "Not necessary to test; our dairy cows are neat, fine, healthy cows as can be found in the state." (But the experience of this Station shows that external appearance is not a safe guide in such cases.)

87. "It exists in herds containing about 150 cows. Cattle in three herds have responded to the tuberculin test." (Akron.)

90. "I believe that Holmes county is almost if not entirely free from tuberculosis in our native cattle. We have only a few large herds and I have had them under close observation for 12 years, and have failed to see any symptoms

of this disease. I have found a few cases in cattle brought in from other parts of the state, which have been destroyed."

91. "I am fully satisfied from the few tuberculin tests I have made here, that the disease is quite prevalent." (Cleveland.)

93. "Not certain, but have every reason to believe that tuberculosis exists to a certain extent."

94. "Am not aware of any cases at present, but have seen cases owned by milk peddlers, and have seen more among cattle furnishing butter."

96. "I have found three cases in my practice of 20 years." (Toledo.)

99. "It was discovered by a veterinary surgeon some time ago. He has since died and nothing further has been done." (Steubenville.)

In addition to the foregoing, several persons give a simple affirmative reply to the question or indicate that they believe that the disease exists in their vicinity but have not positive evidence.

In reply to the second question, only ten correspondents report the use of tuberculin.

Taken as a whole the responses to this circular indicate that bovine tuberculosis has only been positively identified in a few districts of the state, chiefly in the vicinity of the larger cities, where cattle are kept in herds of considerable size. They do not prove, however, that there may not be a much wider distribution of the disease than that indicated, because the tuberculin test has been applied in so few cases that it is impossible to speak with certainty on this point, a fact which many of the reporters recognize. It would seem to be a conservative statement that the disease is to be found in many of the herds of dairy cows supplying our larger cities with milk; that it also exists in some of the country districts, but that there are considerable areas, embracing, possibly, the greater portion of the state, within which it has not yet obtained a foothold

MUNICIPAL INSPECTION OF MILK AND MEAT IN OHIO.

The following replies to the third and fourth question of our circular show the present status of municipal inspection of milk and meat in the state:

2. "For about three years I have been trying to get proper inspection of our dairies and milk supply, but as yet no results have been attained. We have a splendid Board of Health, composed of the best men in the city, but our hands are tied by the city council. Meat inspection is also neglected, yet our sanitary policemen make a haul of fish, etc. at times and also look after some of the dairy yards, but we can get no satisfactory results. I believe that our city councils should take second place when it comes to sanitary regulations. (From the Health Officer of a city of 16,000 population.)

3. "None by the city, but there is governmental inspection of meat here." (Cleveland.) [Governmental inspection applies only to meat intended for inter-state or export trade.]

5. "I am sure that you are engaged in a good work, and hope it will be productive of much good. That milk, dairy and meat inspection is of much

importance there is no doubt. In my duties as veterinarian I have seen cattle affected with actinomycous, cancerous and other malignant affections; cases that could not be treated successfully, and have recommended their destruction, but in many cases these same cattle have surreptitiously reached the butcher's block. Our people do not demand meat inspection, and so long as they (as well as many members of boards of health) are not informed as to the various possibilities of infection and danger from diseased, unwholesome or innutritious meat, and so long as they are not convinced of the transmission of diseases of animals to man, but little improvement can be expected. Some of those who are supposed to be guardians of the public health are criminally indifferent; others know better, and I hope the time will soon arrive when municipal meat inspection will be as rigid as the federal inspection is at present. (Coshocton.)

7. "We are furnishing a chemical and bacteriological laboratory." (Youngstown.)

8. "The local Board of Health has had the sanitary policeman visit the dairies several times to see if they were clean." (Xenia.)

14. "We inspect the dairies two or three times a year." (Washington C. H.)

15. "During August the meat markets were inspected once a week." (Wapakoneta.)

18. "There are a great many irresponsible parties delivering milk in our city, but our Board of Health has not taken any steps to ascertain the character of the milk supplied." (Ravenna.)

19. "We inspect all dairy cows, as well as cans, milk houses, etc. and also test milk taken from wagons in the street. This is done every month. We also inspect all slaughter houses and meat markets every week." (Tiffin.)

21. "During the summer the Board of Health took the matter up and there was an effort made, supported by the physicians, to get a milk inspector; but as the city had no funds to pay an inspector none was appointed. I am not sure that any attempt has ever been made at meat inspection in this city." (Springfield.)

22. "A veterinarian accompanied the committee of the Board of Health when examining the cows and stables of the dairies supplying the town with milk." (Sidney.)

23. "Only by getting samples of milk from the wagons." (Sandusky.)

27. "All milk sold in the village has been inspected during the last month, and dairies will be inspected in a short time. There is no systematic inspection of meat. It is a matter the Health Officer is expected to look after." (Reading.)

29. "Dairies are inspected once a year." (Warren.)

31. "An unsuccessful attempt has been made at meat inspection. No milk inspection." (Circleville.)

34. "Regular ordinary inspection of cows, stables, dairy products and meats provided for." (Portsmouth.)

37. "General attention of Health Officer and examination of milk by ordinary tests. Ordinary inspection of meats." (Piqua.)

43. "Dairies are inspected frequently. General inspection of meat." (Niles.)

49. "There has not been any action taken anywhere in Northwestern Ohio, outside of the larger cities, and I am sure the people here eat lots of diseased meat." (Leipsic.)

54. "I was appointed milk and dairy inspector over two years ago, but only with a view to getting our village supplied with clean, natural milk. Thus far we have accomplished much, but no scientific test has been made to determine whether or not our cattle are affected with tuberculosis. At the same time I was also appointed meat inspector, but to look after its cleanliness only, rather than its healthfulness." (Kent.)

56. "Only that our sanitary policeman regularly visits butcher shops and slaughterhouses." (Hillsboro.)

58. "No inspection. I have recently seen cholera hogs and tuberculous and actinomycosis beef upon the butcher's block."

59. "No inspection. I have been a careful observer of our markets, slaughterhouses, etc., and have noted in one instance pearly tuberculosis of the pleura, and several times animals in advanced stages of pregnancy. We have frequent deaths from acute tuberculosis."

64. "Dairies are inspected twice a year, March and September. The milk is tested by the Babcock system. The city has a meat inspector, who inspects the animals before they are killed and the meat in the markets." (Findlay.)

65. "Nothing more than that given by our sanitary police." (Elyria.)

67. "We now have no Health Board. Meat inspection is conducted only in the ordinary manner by one inspector, and he has very little authority or support." (Dayton.)

68. "Dairies are inspected. During the two years since inspection has been required there has been a marked improvement in both stock and milk." (Cambridge.)

69. "The Board of Health has rules governing the inspection of dairies, barns and milk, but has never had an inspector." (Ashtabula.)

70. "I think very little attention is directed to the dairies. We have a milk inspector who sometimes tests the milk as it is delivered in the city. The same person is supposed to look after the meat." (Columbus.)

78. "The Board of Health officers visit all dairies once a month and inspect all cows." (Bucyrus.)

79. "The dairy cows and all environment of barns, feed, water, pasture and milk houses are closely watched." (Bryan.)

80. "The meat and milk supply for this city is just what the dealers give us. 'Your eyes are your bargain' with us, and if bad meat and watered milk are foisted upon you, then try another market." (Bellaire.)

91. "No; but our Health Officer is heartily in sympathy with the work. (4) Only a market inspector." (Cleveland.)

95. "To some extent." (Delaware.)

99. "None whatever. Population about 16,000. Cows have been sick and some have died. I do not know what the disease was, as I am not a veterinarian." (Steubenville. Another report from this city states that bovine tuberculosis has been identified in some of its dairies by means of the tuberculin test.)

In several cases these questions are answered by a simple affirmative and in one or two cases it is stated that ordinances providing for inspection are being considered, but the reports show that the vast majority of our people are altogether neglecting to avail themselves of the partial protection from unwholesome food which the law places within their reach, while in those cases where inspection of some sort is attempted it is generally inadequate. Take the case of Columbus, for example, a city of more than a hundred thousand people, with *one* inspector for both milk and meat supply!

BOVINE TUBERCULOSIS IN ITS RELATION TO THE PUBLIC HEALTH.

The statistics of the eleventh census of the United States show that 49,844 deaths occurred in Ohio during the census year. Of this number, 6,884, or 14 percent, were ascribed to tubercular diseases, including consumption, hydrocephalus, scrofula and tabes; these last named diseases, together with diseases of the bones and joints, being classed as generally tubercular in character. Of the deaths from this group of diseases, 382, or 5 percent of the whole number, occurred before the age of two years. For the next thirteen years of life the average deaths from tubercular diseases averaged only 27 per annum; but for the 20 years following, that is between the ages of fifteen and thirty-five, more than one-third of the deaths from all causes were due to this one fearful scourge, the proportion rising to 40 percent during the ten years, between the 20th and 30th years of age, the period covering the radiant middle forenoon of life, when life is sweetest and its possibilities are greatest. Says Dr. James Law:

> "If the 5,490 deaths from tuberculosis, which occur every year in the city of New York, could be brought together in an epidemic lasting but one week, no smallpox, cholera nor yellow fever scare would approach the panic which would thus be created; for when did all three diseases together create such mortality in this city? Nay, if we take the whole civilized world and compare with the tuberculosis mortality all the accumulated deaths from war, famine, plague, cholera, yellow fever and smallpox, we find that the latter are comparatively insignificant. Yet, tuberculosis, like every germ disease, is absolutely preventible, and is allowed to continue its career of death only because of reprehensible ignorance and criminal indifference."[22]

During the middle ages consumption was regarded as a contagious disease, and the possible identity of this disease in animals and men was recognized in laws in Italy and Spain, which, according to Dr. Law,[23] are still in force, prohibiting the use of tuberculous carcasses for human food.

At a more recent period the theory of contagion in consumption was almost completely displaced, in our country at least, by that of heredity, and when families were swept away by this scourge it was taken as a manifestation of this great law of life.

In 1865 Villemin demonstrated the communicability of tuberculosis by producing the disease in rabbits and guinea pigs through inoculation, and in 1882 Robert Koch, of Berlin, published his epoch-marking discoveries previously referred to.

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[22] Cornell University Agricultural Experiment Station, Bulletin 65.

[23] Ibid.

THE IDENTITY OF TUBERCULOSIS IN MAN AND THE LOWER ANIMALS.

For centuries it has been observed that many of the lower animals are affected with a tuberculous disease, similar in its manifestations to consumption or scrofula in the human subject, and the identity of the disease has been suspected, as shown by the laws already alluded to. The possibility of transmitting human tuberculosis to the lower animals has been demonstrated by a multitude of experiments since its first discovery, both by inoculating animals with tuberculous materials derived from man, and by feeding them such materials. The counter proof of the communicability of the disease from animals to man is more difficult of demonstration, especially because of the insidious nature of the disease, on account of which its germs may lie apparently dormant in the system after infection, even for years, before distinctly manifesting their presence; but the facts that the bacteriologist is unable to discover any specific difference between the tubercle bacillus found in man and those found in the various domestic animals, and that the manifestations of the disease and the lesions produced by it are so closely alike in all cases,[24] together with the many instances reported since physicians have had their attention turned in this direction, in which the development of tubercular disease in persons, chiefly children, has followed in close sequence upon the use of the milk of tuberculous cows, leaves no room for reasonable doubt that one form, at least, of tuberculosis is common to man and beast. I quote a few cases of this character,

Dr. James Law says, in the bulletin previously referred to: "In the practice of Dr. Stang of Amorback, a well developed, five-year-old boy, from sound parents, whose ancestors on both male and female sides were free from hereditary taint, succumbed, after a few weeks illness, with acute miliary tuberculosis of the lungs and enormously enlarged mesenteric glands. A short time before the parents had their family cow killed and found her the victim of advanced pulmonary tuberculosis. (Lydtin.)

"Dr. Demme records the cases of four infants in the Child's Hospital at Berne, the issue of sound parents, without any tuberculous ancestry, that died of intestinal and mesenteric tuberculosis, as the result of feeding on the unsterilized milk of tuberculous cows. These were the only cases in which he was able to exclude the possibility of other causes for the disease, but in these he was satisfied that the milk was alone to blame.

[24] The report of the Massachusetts Board of Cattle Commissioners for 1897 contains a report of experiments made by Dr. Theobald Smith, in which cattle inoculated with cultures of tubercle bacili derived from bovine tuberculosis showed, at the end of two months time, extensive tubercular infection. whereas other cattle, inoculated with cultures derived from the sputum of human tuberculous subjects, furnished only very slight evidence of such infection.

From these experiments Dr. Smith concludes that bovine tubercle bacilli and human bacilli as found in sputum are not identical, and that there is probably but little danger of cofumigating tuberculosis to cattle through the sputum of tuberculous attendants.

It would seem, however, that no difference greater than that of variety can be claimed from these experiments, for it seems that tubercular growths were found in the cattle inoculated with the human sputum, though their state of development, at the end of two months, was far inferior to that from tubercle cultures of bovine origin. The experiments were of too short duration to show what might have been the condition of the cattle at the end of one or two years—a very important point in the study of a disease so slow in its development as tuberculosis is frquently found to be.

Admitting that a varietal difference is shown, which is all that is claimed for them by Dr. Smith, these experiments throw no definite light upon the communicability of bovine tuberculosis to man, nor do they afford any conclusive evidence that bovine tuberculosis might not be more dangerous to man, as well as to cattle, than the human variety.

"After a lecture of the author's at Providence, R. I., a gentleman of North Hadley, Mass., a graduate of the Massachusetts Agricultural College, publicly stated that his only child, a strong, vigorous boy of one and one-half years, went to an uncle's for one week and drank the milk of a cow which was shortly after condemned and killed in a state of generalized tuberculosis. In six weeks the child was noticeably falling off and in three months he died, a mere skeleton, with tuberculosis of the abdomen. The father could trace no tuberculosis among his near ancestors, but the mother's father and uncle had both died of it. She remains in excellent health.

"Dr. E. O. Shakespeare (Med. News, March 26th, 1892) attributed one-fifth of all deaths in infants and young children, feeding on milk, to tuberculosis, usually commencing in some part of the digestive organs.

"The identity of tuberculosis in cattle and in man is abundantly proved in the above instances of the infection of man through the milk and in the hundreds of cases in which the tubercle of man has been successfully inoculated on the lower animals. As evidence of direct transference of the disease from cattle to man by inoculation the following two cases are quoted:

"Tscherming, of Copenhagen, attended a veterinarian who had cut his finger in making a post-mortem examination on a tuberculosis cow; the wound healed but there remained a swelling which soon ulcerated and refused to heal, so that the whole tumefied mass had to be cut out. The microscope revealed the distinct tubercular process and the presence of the characteristically staining bacilli.

"Pfeiffer attended a Weimar veterinarian of the name of Moses, 34 years old, of a good constitution, and without hereditary predisposition, who, in 1885, cut his right thumb deeply in making a post mortem examination of a tuberculous cow. The wound healed but six months later the cicatrix still remained swollen, and in the autumn of 1886 the man had pulmonary tuberculosis with bacilli in his sputa and death occurred in two and a half years after the wound. Post-mortem examination revealed tuberculosis of the joint of the wounded thumb, and in the lungs extensive tubercles and vomicæ.

"To Tscherming's may be added the case of a young veterinary friend of the writer, who was inoculated in the hand in opening a tuberculous cow, and suffered from a tumefaction of the resulting cicatrix, with distinct tubercle bacilli. The surgical removal of the tumefaction manifestly saved the subject from a generalized tuberculosis."

In addition to the foregoing, I quote the following instance from Bulletin 42 of the Vermont Experiment Station:

"A child four years old, great grandson of Henry Ward Beecher, died last March at Yonkers, N. Y., of tubercular meningitis. The diagnosis was confirmed by specialists. There were no hereditary tendencies to the disease known. The certainty that he had the disease, and the inability to account for it from human agencies, led the physicians to suspect the milk of the two Alderney cows, on which the child had been mainly fed. Both the tuberculin test and the post-mortems showed that both animals were tuberculous. Through the kindness of Dr. J. S. Lamkin of Yonkers, who made both tests and post-mo tems, sections of the lungs and a gland were sent to us. They were found to be highly tuberculous."

Dr. M. Stalker, veterinarian of the Iowa Experiment Station, reports the death from consumption of five young people, between 20 and 30 years of age, in one family during a period of two years. Not a trace

of the disease had ever been known in the family of either the father or mother of the victims. On the farm where the deaths occurred he found 17 cases of tuberculosis in the herd of cattle, and others had died before the investigation was made. In another case, reported by the same authority, a mother and child died; "The mother from undoubted consumption, and the child from intestinal trouble highly suggestive of the same disease. The cow that had supplied milk to the mother and child was tested and found to be tuberculous. Post mortem examination of the cow revealed a badly tuberculous condition of the udder."[24]

In the year 1890 Dr. Harold C. Ernst, of the Harvard Medical School, under direction of the trustees of the Massachusetts Society for Promoting Agriculture, sent out to about 1,800 medical and veterinary gentlemen a circular, inquiring whether they had ever seen cases of tuberculosis which it seemed possible to trace to a milk supply as a cause. A thousand replies were received, only few of which gave well confirmed instances of the transmission of this disease through cow's milk to human beings; a considerable number reported suspicious cases, and many expressed their belief in such transmission, but stated that they were unable to offer evidences in support of such belief, that would be accepted as scientifically satisfactory.

Some of the uncertainties in such an investigation are to be found in the fact that the disease may be latent in the system for years, when the subject takes what is commonly called a cold and develops other symptoms which may be ascribed to atmospheric influence and not to the food supply. Or, in the case of the dwellers in cities, there is usually no possibility of tracing the milk to its source and thus determining its character; but the chief difficulty in this investigation seems to have been due to the lack of interest in the matter on the part of a very large proportion of the medical gentlemen consulted.

Among the cases of suspected transmission of tuberculosis through cow's milk to children reported by Dr. Ernst are the following:

Dr. A. B. Coffin, of Roxbury, reports the case of a baby in a family with no past history of tuberculosis, which "never prospered, lost flesh, developed a bronchitis and large belly, much swollen." The general symptoms indicated tabes mesenterica. The baby was fed on a Jersey cow's milk, uncooked. The cow died and the baby soon after, but no opportunity was given for post-mortem examination in either case.

Dr. Israel T. Dana, of Portland, Maine, writes: "I have had cases of infants brought up on cow's milk, when neither heredity nor environment would lead to the expectation of tuberculosis, in which tuberculous symptoms have rapidly developed, with fatal terminations. The symptoms have oftener been abdominal than pulmonary."

Dr. J. Arthur Page, of Lowell, Mass., reports the death of a child from tubercular meningitis. The family history was good, and the food consisted (aside from breast milk) only of milk from one cow. Rabbits inoculated with

[24] Iowa Agricultural College Experiment Station, Bulletin 29

this cow's milk, died, but no definite sign of tuberculosis was found in the cow. This, however, was before the introduction of the tuberculin test.

Dr. Geo. H. Bailey, State Veterinary Surgeon, Portland, Maine, writes: "I have a case now under observation where about a year ago I condemned a tuberculous cow, that proved upon post-mortem to be an advanced case of pulmonary tuberculosis. The milk from this cow was the sole supply of the family (a man and his wife) and although there is no history in the family of the woman that can possibly be traced to pthisis, she is in an advanced stage of consumption, as I have every reason to believe from the direct use of the milk from the cow that I condemned."

Dr. N. Senn writes: "I have seen a number of cases of intestinal tuberculosis in children fed on cow's milk, in which other causes could be excluded."

Dr. G. T. Whittaker, of Cincinnati, states that he has had one or two cases of basilar meningitis, secondary to intestinal affections and independent of bronchial catarrh, in new houses, parents and attendants free from all signs of the disease, with no trace of it even in remote ancestry, and the surroundings (rural) perfectly good. The milk was taken from one cow in each case, and intestinal catarrh was the forerunner of the meningitis.

Dr. C. H. Peabody, Veterinary Surgeon, Providence, R. I., reports the case of a cow which gradually went down with evident symptoms of tuberculosis. He advised her destruction and remonstrated against the use of the milk, but with no avail, the family continuing to use it. The cow finally died and autopsy showed generalized tuberculosis. A few months later the baby of the family died, and post-mortem examination showed tubercular deposits in brain and lungs; two years later a child, three years old, died with tubercular bronchitis, and a few years later a boy nine years old, who had been delicate for three or four years, died with "quick" consumption. The parents and grandparents of the children were all rugged and healthy people.

Dr. A. R. Rose, D. V. S., of Littleton, Mass., reports the case of a child that died with tuberculous symptoms after living upon the milk of a tuberculous cow.

Dr. Edward T. Williams, of Roxbury, Mass., writes: "I think I have seen many examples of tubercular disease from milk, mostly in hand-fed babies of perfectly healthy parentage, developing tabes mesenterica, pthisis, and tubercular meningitis, yet I cannot prove it scientifically in any case."

Numerous others write to the same effect. For instance, Dr. F. Forchheimer of Cincinnati, writes: "According to my notion, tuberculosis is by far the most common of children's affections,—again, most common in a localized form. The place where it is most frequently found in them is somewhere in the alimentary tract or organs connected with it. Milk is the most common article of diet in children; milk contains tuberculous material to an extent which, according to my idea, is not properly estimated, so that I have the conviction that tuberculosis is frequently caused by milk. As to a record of cases of this connection, or scientific proof of the same, I should hesitate a very long time before I would put down any individual case as in evidence. Cases are not uncommon, in practice, in which a tuberculous mother nurses an infant which dies, let us say, of meningitis tuberculosa. Yet, in such a case, in which I am convinced that the mother has transmitted tuberculosis to her child, how can I present evidence sufficiently conclusive to prove that the infection has not come from another, extraneous source? I have seen children who, according to the statement made to me, have had no other food but milk, with the following set of lesions: tuberculosis of the glands about the neck, of intestines, mesenteric glands, lungs, and meninges. I am justified, I think, in the conclusion that the tuberculosis

was produced by a something introduced into the alimentary canal. I am convinced that it was by means of milk, yet I am not justified in this individual case in stating that this was the cause to my knowledge. In other words, I cannot put down such a case as one capable of exact demonstration."[25]

If it be true that human and bovine tuberculosis are identical, then we should expect to find human tuberculosis more prevalent among people who keep cattle largely, and use their flesh and milk for food. Upon this point I quote from the report of the New York Commission on Tuberculosis in Cattle, as given in the Fifteenth Annual Report of the New York State Board of Health:

"Broad generalizations of our knowledge show a close parallelism between the numbers of dairy cows and the prevalence of tuberculosis in the human race. Countries that have few or no cattle, or in which the herds are mainly kept in the open air, and are, therefore, largely protected from the disease, show as a rule little tuberculosis in man. Thus phthisis is rare in the Scottish Hebrides, Iceland, New Foundland, Hudson Bay, Northern Norway, Sweden, Lapland and Finland, China, Japan, the Kirghiz Steppes, and most of the Pacific Islands. Striking exceptions have to be made which are in themselves very instructive. The Sandwich Islands have become an exception since the introduction of European cattle. Australia and Tasmania, which 30 years ago were considered as incompatable with consumption have, under the advent of phthisical persons and an extensive ranching, become almost as tuberculous as England itself.

"In the Kirghiz Steppes the Tartars keep horses rather than cattle, eating their flesh and drinking their fermented milk, and they rarely suffer from tuberculosis. In Italy, on the contrary, in the balmiest climate of Europe, the consumptives congregate from all points; the numerous cattle are kept, to a large extent, indoors, and Perroncite pronounces tuberculosis as a veritable scourge for man and beast. In the early days of its settlement, Minnesota was looked upon as nature's sanitarium for the consumptive, but now with the advent of domesticated herds, tuberculosis has become about as prevalent as elsewhere. In China the ruling Tartar race, eating beef and milk, suffer largely from tuberculosis, whereas the poor aboriginal Chinese, living mainly on rice, are but rarely attacked. The same exemption is largely the prerogative of the vegetarian Japanese. Holden tells us there is little or no consumption in Columbia, where little milk and no butter is used, and that the same is true of Ecuador and the internal parts of the Argentine Republic.

"When we turn to our own American Indians, the reverse of this picture appears in all its hideousness. These are in the habit of eating raw the cattle provided for them, and which, being bought in the cheapest markets, are not always sound. Dr. Holden, in the Medical Record for August 13, 1893, tells us the result. At Green Bay, Wis., Tualip, W. T., and Western Shoshones, Nev., tuberculosis causes 50 percent of the total Indian mortality. Dr. Treon, in the American Practitioner, refers to the consumption of the raw diseased meat at the Crow Creek Agency, in these terms: 'Saturday, early in the morning, the cattle are shot down in the corral, and the Indians drag them out, skin and cut them up. I have observed them frequently, when slaughtering, eating the warm liver, tallow and even the entrails, and great quantities of raw beef. In fact, much of the beef is dried, pounded up and eaten without cooking. Frequently they eat

[25] Infectiousness of milk. Result of investigations made for the trustees of the Massachusetts Society for Promoting Agriculture. Published by the Society. Boston, 1895.

animals that have died of disease days before, and, to my mind, here is a good solution of the trouble: Supposing that only one out of a thousand cattle received be affected with tuberculosis or actino-mycosis, from the manner of dividing the beef it is possible, and probable, that 100 persons may become inoculated by a single diseased animal.' These are extreme examples, it is true, but they are terribly significant when taken in connection with the fact that the one essential cause of tuberculosis is the living germ, and that this germ is indistinguishable in the diseased animal and in man. It matters not to tell of the overcrowding and unhygienic condition in which these Indians live. The Esquimaux live in huts just as close throughout a still longer winter, but in the absence of the infected food show no such terrible results."

The question may now be raised, why is it, if this disease is really communicable from animals to man, that it has taken so long to establish that fact? The answer is to be found in part in the narrow field occupied by the practice of medicine until a very recent date. Although Hippocrates, Columella and others wrote concerning the diseases of animals, such diseases were not considered worthy the attention of the student until 1761, when the first veterinary school was established at Lyons, and it was thirty years later before a similar school was permanently established in England. Up to this time the farrier was the only veterinarian, except when his field was encroached upon by the professional quack.

This state of affairs gradually gave way to a somewhat improved condition in Europe, as the veterinary schools began to turn out men having better qualifications for their work; but men of middle age will remember the time when in Ohio the local "horse doctor" was probably one of the most ignorant men in the community, and when the average practitioner in human medicine felt it to be altogether beneath his dignity to study the diseases of the lower animals.

The practice of veterinary medicine will always remain a separate vocation from that of human medicine; but both must now be built upon the same broad foundation which has been laid for them by the comparative anatomist and physiologist.

This former disregard of the lessons which might have been learned from a careful study of the forms of disease in the lower animals was perhaps the chief cause of failure to recognize fully the identity of tuberculosis in man and animals. Another cause is found in the insidious nature of the disease, already referred to, rendering it possible for the visible outbreak to be delayed for an indefinite period after the actual infection has taken place, or causing the disease to be communicated by animals which themselves appear to be in the most perfect health; for it is one of the singular characteristics of this malady in cattle that the healthiest appearing animal in the herd may be seriously affected with tuberculosis.

The general belief in the heredity of consumption has also contributed to obscure its true nature. In the light of our present knowledge

we must abandon this belief, unless we include congenitalism under the general term, heredity. Possibly there may be pre-natal transmission of tuberculosis from parents to their immediate offspring; but this transmission must be regarded as of the same character as infection, and not at all as due to that law by which physiological and psychological characteristics are transmitted from generation to generation, further than that the physiological peculiarities favorable to the disease, if there are such, may be thus inherited. Even congenital transmission is doubted by so good an authority as Carl Frænkel, who denies that "a single indubitable case of congenital tuberculosis (established before or during birth) has thus far been observed in man." Referring to the discovery of tubercle bacilli in the embryos of cattle he says:

> "But we can surely object that these observations are decided exceptions to the rule. We are far from saying that such a thing cannot happen, but it has as yet not been established, and all cases of tuberculosis occurring during the first months of life thus far communicated have proved open to the suspicion that they are the result, not of an inherited affection, but of one acquired at a very early period, i. e. a genuine infection."[26]

In illustration of this point I have compiled the following table from the reports of the Eleventh Census of the United States, showing for Ohio the total annual deaths from all causes at different ages of life, the total deaths ascribed to consumption, hydrocephalus, scrofula and tabes combined, and the proportion which these bear to the whole. Hydrocephalus is classed in the census with tubercular meningitis, in the belief that most cases of death ascribed to hydrocephalus are due to tubercular meningitis. Scrofula and tabes are now also looked upon as essentially tubercular diseases. Hydrocephalus, scrofula and tabes are especially destructive in the earlier years of life, and therefore it is necessary to consider them in a study of tuberculosis by age periods. These do not exhaust the list of tubercular diseases, as certain diseases of the bones and joints should be included, and it is probable also that a considerable proportion of the deaths ascribed to diseases of the bowels and liver, to debility and atrophy, to bronchitis and to diseases of the brain other than those mentioned are due principally to tubercular infection. On this point Dr. E. O. Shakespeare, of the University of Pennsylvania, has expressed the belief that one-fifth of all deaths in infants and young children, feeding on milk, are due to tuberculosis, usually commencing in some part of the digestive organs.

The table gives the figures for each year separately under five years of age, and for the annual average of the five-year periods following that age:

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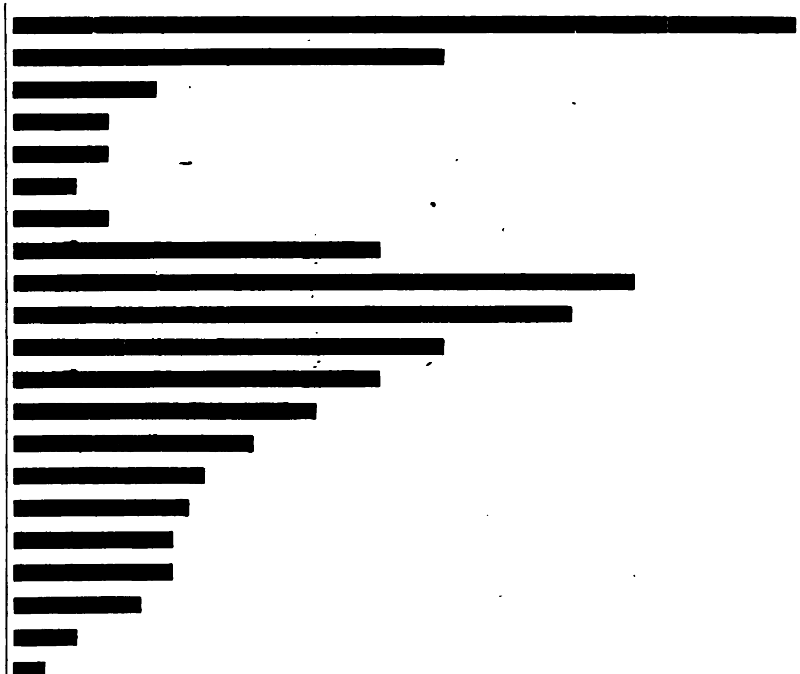
[26] Textbook of Bacteriology, Linsley's translation, 1891, p. 245. Since this was written, however, there have been reported a few cases in which congenital transmission seems to have been well established.

DEATHS IN OHIO DURING THE CENSUS YAER AND PROPORTION DUE TO TUBERCULAR DISEASE.

Age periods.	Deaths for each age-year.		
	From all causes.	From tubercular disease.	
		Total.	Percentage.
r 1 year	10,274	245	2.38
2 years	2 662	137	5.14
3 "	1,409	45	3.19
4 "	973	32	3.19
5 "	732	32	4.37
10 "	436	21	4.82
15 "	227	29	12.78
20 "	359	116	32 31
25 "	484	196	40.49
30 "	438	174	39.72
35 "	392	138	35 20
40 "	376	118	31.38
45 "	348	96	27.87
50 "	335	77	22 97
55 "	356	59	16.57
60 "	376	56	14.63
65 "	441	49	11.11
70 "	504	49	9.72
75 "	524	41	7.82
80 "	466	21	4.51
85 "	348	10	2.81
ges.			



This table shows that more deaths occur from tubercular diseases before the first year of life is ended than during any following year, although the percentage of such deaths to the total mortality is comparatively small, owing to the tremendous destruction of life from other causes at this period, a destruction amounting to one-sixth of all the deaths in Ohio, as shown by our state statistics, and extending to twice that proportion in some of the foreign born populations of the cities, as shown by the statistics of the National census.

As already suggested, it is probable that the figures for the deaths from tubercular diseases in early childhood are much too low, and that their exhibit of the enormous loss of life, as compared with the relatively smaller losses between the third and fifteenth years, is far below, rather than above the truth.

Congenital infection might account for these early deaths if there were no more probable hypothesis; but the fact that the absolute demonstration of such infection has been so rarely if ever made, while the opportunities for external infection are so very great, must lead us to doubt whether even congenitalism, saying nothing of heredity proper, plays any important part in the propagation of this disease. If the disease were largely of congenital origin we should expect to find a condition of affairs in cattle similar to that shown by human statistics; but in fact, tuberculosis is extremely rare in cattle under twelve months of age, and is practically unknown at the age which would correspond to the first year of human life. When found in cattle under a year old it may be almost invariably traced to the milk of tubercular dams or to close association with older tuberculous cattle.

Bang of Denmark reports the case of a herd of 208 cows in which 80 percent of the cows and 40 percent of the calves were found infected. The infected animals were then isolated and their calves removed immediately after birth, placed in disinfected stables and fed with boiled milk, after which they remained free from the disease.[27]

Voges calculates, from the examinations of nearly 2,000,000 calves, butchered in various German cities, that only about one in 200,000 had inherited tuberculosis.[28]

Nocard reports that in a region where 15 to 25 percent of the cows were affected only 1 per thousand of tuberculous calves were found, and from other tuberculin studies where 40 to 80 percent of the cattle were affected calves from 4 to 15 months old were not found diseased. In one case, of 44 calves, 6 to 18 months old, 33 were sound, and of the dams of these 26 were tuberculous.[29]

At the Ohio Station the calves are taken from their dams at 3 days of age, and fed by hand thereafter. In one case we have purposely

[27] Abstract of report in Experiment Station Record, Vol. VI, p. 574.
[28] Ibid, Vol. IX, p. 993.
[29] Ibid, Vol. X, p. 94.

produced tuberculosis in a calf under 6 months of age by feeding it milk from tuberculous cows, and we have had two cases of development of this disease in calves at 4 and 5 months of age; but in both cases the dams were in advanced stages of tuberculosis, and the calves had been fed on their milk untreated for the first three days after birth, although receiving only pasteurized milk thenceforth.

It is evident, from these investigations, that the great majority of calves are born free from this disease, even from infected dams, and there would seem to be reason to believe, with Frænkel, that the same law may hold good in the case of children, and that the mortality of infants and young children from tuberculosis may be due almost altogether to post-natal infection.

Such infection has been shown to come through the milk of tuberculous mothers; through the kissing of tuberculous nurses and friends; through handkerchiefs which have been used by the tuberculous; through the accumulation of tuberculous dust in living rooms — and here let me again refer to Frænkel, who quotes the experiments of Cornet, which showed that the dry, powderly dust found on the floors and in the recesses of dwellings inhabited by consumptives almost invariably produced tuberculosis when injected into the peritoneal cavity of guinea-pigs; the diseases beginning in the abdominal organs and only slowly, if at all, extending to the lungs, which are the organs first affected in the spontaneous tuberculosis of these animals. When the inoculating dust came from places where there had been no consumptives the animals showed no symptoms of tuberculosis. Cornet further showed that the chief vehicle for the distribution of tuberculous material is the handkerchief, on which it dries and from which it is unthinkingly shaken off. Dr. J. H. Kellogg, of Battle Creek, Mich., gave a striking instance of such infection, in a paper read before the National Live Stock Sanitary convention held in Washington, in June 1894.

The statistics of the eleventh census show with remarkable reiteration that the death rate from consumption is lowest among the native-born whites of native-born parentage; that when either of the parents is foreign-born the death rate increases; that there is a still further increase when both parents are foreign-born, and that the rate is more than three times as high among the colored as among the native-born whites of native parentage. In other words, the death rate from consumption is lowest among peoples of cleanliest habits and highest among those of opposite habits.

Immunity from consumption is not to be secured by personal cleanliness alone, however. The half swept floors of public halls; the too often not half swept stairways and corridors leading to business offices; the sidewalks, rendered filthy by the expectoration of heedless passers-by, all these are sources of contamination which the cleanliest cannot wholly

escape; and when the children which have escaped the disease at home are started to school they begin running a gauntlet of infection, the risks of which will constantly increase as they grow older and gradually enter upon the busy work of life.

On these grounds it is easy to account for the rapid increase in deaths from tuberculosis at the age when this increase is shown by the statistics; but there can hardly be room for doubt that the enormous infant mortality from this disease is due, not only to the causes mentioned, but also to the use of milk from tuberculous cows.

In the hope of obtaining additional information upon this last point the following circular was sent in November, 1898, to the physicians of Ohio.

OHIO AGRICULTURAL EXPERIMENT STATION.

INQUIRIES RESPECTING TUBERCULAR DISEASE.

To Physicians:

Please reply to these questions with at least a yes or no (it is hoped that you will find time to give additional particulars), and mail, with your address, to

Experiment Station, Wooster, O.

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1. Is your practice chiefly in the city or country?
2. Have you found bottle-fed infants to be relatively more subject to tubercular disease than those nourished exclusively at the breast?
3. Have you been able to trace any cases of tubercular disease to the milk of unhealthy cows? If so, please give particulars.
4. In the case of bottle-fed infants, have you observed greater or less frequency of tubercular disease among those fed from single cows than among those receiving the mixed milk of large herds?
5. Have you had reason to suspect the origin of tubercular disease in older children or adults to be in the milk or meat supply? If so, please give particulars.
6. In the case of breast-fed infants have you observed tubercular disease when the mother was not herself tuberculous?
7. If so, was there a tuberculous attendant or frequent visitor?
8. Or, had the house been previously occupied by a tuberculous person?
9. Have you had any reason to suspect the communication of tubercular disease from infants to adults?

Three hundred and thirty-nine replies to this circular have been received from physicians practicing within Ohio.

Of these replies, 116 were based upon city practice, 153 upon country practice and 67 upon both.

One hundred and thirteen physicians answered the second question in the affirmative and 189 in the negative. Of those who reply in the affirmative many add the qualification that bottle-fed infants are more subject to all diseases, while many of those who reply in the negative are physicians practicing in the country, who state that they have had either too few bottle-fed infants, or too few cases of infantile tuberculosis under their observation to justify conclusions on this point. On the other hand, two or three physicians record the observation that bottle-fed infants are less liable to tubercular disease than those nourished at the breast; others modify this by the qualification "provided the milk is sterilized," and many say that the bottle is safer if the mother is tuberculous.

Affirmative replies to the third question are given by 22 physicians, and to the fifth by 33. Several cases are reported in which the sequence of tubercular disease upon the use of infected milk or meat is so close as to leave little doubt that the disease has been acquired in this manner, but the difficulty of producing a scientific demonstration of this causal relationship is alluded to by them and by others, who state their belief in the communication of the disease through the food, but can furnish no facts in support of that belief.

In answering the fourth question, the great majority state that they have observed no difference between the milk of single cows and that of herds. Many write from the cities that mixed milk is the only milk available, while those from the country usually state that no large herds are kept. Forty-one express a preference for the milk of single cows, and 32 for the mixed milk of herds.

Of the 339 reports, 109, or less than one-third, have observed any cases of infantile tuberculosis when the mother was not herself tuberculous; 49 of these observers knew of there being a tuberculous attendant — the father in nearly half the cases, frequently aunts or sisters or other relatives — or of the house having previously been occupied by tuberculous persons, and 39 more were doubtful upon these points, while 21 answered both questions by a simple negative.

In answering the seventh and eighth questions many intimate that attention had not been drawn to these possible sources of infection; on the other hand, in several cases tubercular disease of adults is ascribed to contaminated houses.

Twenty-eight report observations of tubercular disease from infants to adults, and 34 have observed its communication from one adult to another.

Taken as a whole, the great majority of these replies from physicians indicate a belief in the contagiousness or infectiousness of tubercular disease and its possible communication from cattle to men through the medium of milk and meat.

Many of the physicians, in replying to the circular, added observations of great value, which are here given in condensed form, the prefixed numbers indicating the order in which the replies were received, and the numbers in parentheses referring to the questions. In the case of the omitted numbers the replies were limited to a brief affirmative or negative. The place from which the reply was received is given at the close, and the character of the writer's practice is indicated by the Words "city," "country" or both.

2. An Irish family nearly all died with consumption about the years 1883 to 1887. The father and mother were both born in Ireland, of healthy parents. The first girl took sick about the year 1883, with well developed tuberculosis, and died. Two other girls afterwards died of the same disease, also the father.

One boy and girl still living. I can only account for this in the milk and meat supply and unhealthy surroundings. (Orrville. Both.)

3. Tuberculous patients should be prohibited by law from expectorating in public places and should be provided with something to destroy the germ which is expectorated. (Coshocton. Both.)

4. A father had tubercular disease and would expectorate on floor and wall and his babe took it and died, as well as his wife and two others of the children. (Wapakoneta. Both.)

7. We have here almost every nation represented, Chinese excepted, and of course they nurse their children if possible, hence I have not had extensive experience with bottle-fed infants. (6) Yes, but two older children had it, with a father dead from most malignant tuberculosis. (Ashtabula. City.)

9. I have a case of an infant whose father died of tuberculosis and whose mother was infected. I never permitted it to nurse the breast. First it was fed on malted milk, later on cow's milk (from one cow) and barley water, and it developed more rapidly than any baby I ever had in charge. It is now about 17 months old. Another: Both parents died of tuberculosis. Fed the babe on cow's milk and barley water, but it was kept much of the time in infected rooms, contrary to orders. It developed tubercular meningitis; recovered from the first attack but had a second four months later and died. (Crestline. Both.)

22. (7) An aunt came into a house and two children died, soon after she did, with tuberculosis. (8) I have seen cases of tuberculosis where the cause was paper in rooms where others had died. (9) Yes, but not so much as adults to infants. (Cleveland. City.)

23. Tuberculosis is of mixed origin — amyloid or albuminoid — due to imperfection in digestion and assimilation, to constitutional types and faulty air, food and hygienic accompaniments. Facts to justify any definite answers to these questions are not at hand. In tuberculosis in young children diagnosis is not clear nor history continuous. (Cleveland. City.)

28. (2) I answer "no" because there has not been any such disparity as to attract my attention to the matter. (3) No, which may be partially due to the fact that I have for many years prohibited the use of milk from city-fed cows. (4) No, because I have always advised the use of mixed milk. (9) No, but I believe it to be entirely possible. (Cleveland. City.)

29. (*a*) We should isolate tuberculous patients and subjects as much as possible. (*b*) Every tubercular subject should be reported to the health authorities. This is far more important than reporting typhoid fever. Doctors should report whether being treated or not. The people should be instructed as to its being contagious and taught prophylaxis. (*c*) Every tenement where a tuberculous patient resides should be carefully watched and before another family occupies the place it should be thoroughly renovated and perfectly cleansed. It seems to me that one of the greatest sources of contagion is being grossly neglected. (Cleveland. City.)

31. Cannot answer questions 2 and 9 definitely because of limited number of cases of tubercular disease in children. (4) Use a mixed milk, pasteurized in all cases. (Cleveland. City.)

32. I have observed a greater tendency to bowel trouble in infants fed from mixed milk than when from a single cow, but cannot say definitely that it was tubercular. (Cleveland. City.)

34. I have had no experience with tuberculosis in babies, unless wasting disease, commonly called marasmus, is tubercular. I have noticed that this disease is very much more frequent in bottle-fed babies. I wish we could have a regular inspection and test of cows, with destruction of those suffering from tuberculosis.

I would recompense the owner for the first five years; by that time cows free from disease would be worth enough more so that owners could afford to lose those diseased. After cows each have a certificate of health I would advise the milk from single cows for bottle-fed babies. I hope you will push experiments in this direction. I am interested in this subject both as a physician and as a stockman. (Medina. Both.)

36. I always have the milk boiled before using it for infants or sickness and generally use lime-water with it. (Westerville. Both.)

37. (2) I have seen very few bottle-fed infants. Most of them died of diarrhœa. (3) I know of no tubercular cows. (10) I know of cases communicated from young adults to their elders. (Bentonville. Country.)

39. Fortunately I have had but limited experience with bottle-fed infants. They are mostly fed on the breast here. (Radnor. Country.)

40. (2) Yes; in general they seem less able to resist disease. (4) No experience; I always direct infants to be fed from single cows. (6) Two cases. (8) One had. (9) In one case I had an infant to die with tuberculosis; since then, in the same house, three adults have died of the same disease. (Stoutsville. Country.)

42. Bottle-fed infants are often allowed to suck the empty bottle to the detriment of the child. They are also given too much milk at one time, hence its coagulation and compaction in the stomach, which is more detrimental than the first named habit. Many years ago I was requested by the Woolgrowers' Association of Harrison County, Ohio, to write an article on the diseases of sheep, and for that purpose made special investigations; one conclusion reached was that the disease called "lamb cholera" results from too large a supply of milk in the dam, with an insufficiency of salt. I found the milk compacted in the stomach, causing a whey-like substance to pass from the bowels, and I believed that the pressure on the heart from the compact mass in the stomach caused the spasms and death of the lamb. (5) Filthy dairies send filthy milk to patrons and there may be various kinds of bacilli in it. I have treated scrofulous patients, the disease resulting from filthy habits and eating raw pork. (St. Clairsville. City.)

43. (3) One child, nourished by milk from one dairy, supposed by myself and others to contain tuberculous cattle; not verified by tuberculin test. (5) Have not observed such cases but believe it is undoubtedly true that meat and milk are the two chief sources. (7) One case, that of a child nursed by a tuberculous wet-nurse. (Martin's Ferry. City.)

45. For a year or more past this section of country has been almost exempt from tuberculosis, while 3 or 4 years ago there were a number of cases. (Damascus. Country.)

50. In sixteen years' practice in this community I have never been able to trace a single case of tuberculosis to the milk supply. The cattle in this vicinity seem to be remarkably exempt from tuberculosis. (Forest. Country.)

55. (2) Most bottle-fed infants of the poorer classes die of acute indigestion, and do not live long enough to develop tubercular troubles. (3 and 4) Mixed milk is so generally used in the city that it is impossible to tell where any given sample comes from. (Cleveland. City.)

57. (3) I recall one case — a child who was fed on the milk from an apparently healthy cow. The babe died of phthisis, and a year or more after the cow became emaciated and died. (7) Yes, a visitor or another member of the family who had the disease. (Lancaster. Both.)

64. I tell my tuberculous patients to be very careful about the sputum — never to deposit on the floor, etc. I never want any one to sleep with one who has tuberculosis nor to be in company with such a one when it can be avoided. There is no doubt that the disease is communicated from person to person, and

the greatest care should be exercised about it, and everything as thoroughly disinfected after a case of it as after any other contagious disease. No one should be allowed to sell milk in towns until his herd is first examined and shown to be free from the disease. The sanitary condition of the stables, cows, and the people who milk the cows should be thoroughly investigated by some one competent to do that work and do it well, without fear or favor. (Urbana. Both.)

65. (8) Child one year old (boy) very much emaciated; looseness of bowels; medicine did but little good; advised to change milk; child recovered in short time and is to-day strong and well. Found cow unhealthy, confined in close stall and poorly fed. I have every reason to believe that the cow had tuberculosis. (Sevenmile. Country.)

66. In reply to your favor, would say, that a careful study of this subject for over 20 years leads me to the following conclusions: (*a*) Consumption is not hereditary in the general acceptance of the word. (*b*) It can only attack or gain foothold in those who are weakened — in other words where malnutrition exists. (*c*) While I admit the truth of the Koch theory, so far as the existence of a parasite is concerned, I do not believe it to be the primary cause of the disease, but the result of it, i. e. the person must be in condition to receive and without power to throw off their influence. (*d*) I believe it to be contagious when those who are in direct personal contact become enfeebled by exposure or otherwise to a weakening of their vital powers, and only then; malnutrition is the forerunner of consumption. (*e*) There is no doubt in my mind but that tuberculosis is communicated from cattle to man, but only to those whose systems are in condition to receive the germs. I take from my book the following points: From 100 cases, children 1-16 years, number of bottle-fed, 17; tubercular trouble in some form, 3; breast-fed, 19; tubercular trouble in some form, 1, with one case doubtful. Of the remaining 64, 2 percent had weak lungs, but have developed nothing as yet. It must be remembered that these cases were among a class who did not take the best care of themselves.

To sum up: I believe tubercular disease can be communicated by milk to those who are fit subjects for it, more than it can be by meat, unless eaten raw, and that if more attention was paid to our meat and milk, tubercular trouble would become quite rare in time. (Columbus. City.)

67. (5) I am of the opinion that this cause is very much overrated. (9) No, but I am positive that adults have communicated it to children, also to adults. I am pursuing investigations along this line at present. I consider the schools a source of contagion. (Columbus. City.)

76. The wife of M—— W—— died of tuberculosis, and after her death his sister went to keep house for him. In two years she died of tuberculosis. Her sister waited upon her, and appeared in good health for several years until she married J—— N——. The parents of M—— W—— then moved into his house, when his mother became sick with tuberculosis at the age of 70 years, and died in a short time. J—— N—— then moved into the same house and had lived there a year when his wife gave birth to a fine, healthy looking boy; but the mother rapidly developed tuberculosis and died, and in a month the babe developed a marked case of tubercular meningitis and died. These last two cases were waited upon by J—— N——'s sister, who became ill with tuberculosis within a year and died with the same dread disease. There was no previous tubercular trouble in the N—— family. (New Market. Country.)

77. (7) Yes, in five cases; the father in one, aunts in three others. (Ada. Both.)

78. I have seen but three or four cases of tubercular trouble in children. A child of 4 years, with pulmonary tuberculosis; a child of one year, with tuber-

cular hydrocephalos: a child of 21 months and one of only a few months with tubercular meningitis. In none of these was I able to trace the origin of the trouble to any cause satisfactory to myself. The last three cases were all bottle-fed, but there are children in each of these families fed in like manner from the same cows that have escaped that dread disease. I instruct my people as to the infectiousness or contagion of the disease, and warn them to be careful accordingly. (Sharonville. Country.)

80. (3) Yes, when cows were kept shut up in small stables and fed mash and slops. (4) Greater frequency in single cows, when city-kept. (5) Can give no particulars that are complete. (6) I know of only one instance. (7) An aunt. (Cleveland. City.)

81. (2) All cases of supposed tubercular meningitis except one or two were bottle-fed infants. (Van Buren. Country.)

85. I think No. 9 can be answered in this as in most other contagious diseases: adults do not contract from children as children do from adults. (Cincinnati. City.)

86. (9) No, because there are so many chances of contagion from adults that are tuberculous. (Columbus. City.)

92. (4) It has so happened that all the tubercular children that have come under my care came from tuberculous parents. (Lancaster. City.)

95. While I firmly believe in the infectious character of tuberculosis, I have never observed the disease following the use of milk but once, and heredity was so marked in that case that I doubt very much that milk was the cause. I still believe that heredity plays the largest part in the propagation of tuberculosis and question whether a person can be infected with the disease who has not inherited the tubercular diathesis, or acquired it by poor food and poor hygienic surroundings. (Wauseon. Country.)

98. (6) I have, in a number of cases. (7) Generally the father had tuberculosis. In all, or nearly all, my cases I could trace it to the father's side, or grandfather — not to meat or milk. (Ashley. Both.)

106. (6) The only cases I have noticed were when the mother was tuberculous. I have had infants taken from infected mothers and placed on the bottle with immediate improvement. Of course we select a healthy looking cow, and only allow that cow's milk to be fed to the infant. (Lyons. Country.)

107. I have had two cases where I thought the disease was communicated from one member of a family to another. I believe that if the instructions sent out by the Ohio State Board of Health (Dr. C. O. Probst, Secretary, Columbus, Ohio) were followed closely the deaths from tuberculosis would be very much diminished. (Fostoria. City.)

108. I believe in hereditary tendency and development by contact. I have observed communication from one adult to another. (Newark. Both.)

109. In the majority of cases it can be traced to contagion. (Norwalk. City.)

110. I have never practiced where there are large dairies, and no cattle in this vicinity have been suspected of being tuberculous. (Georgetown. Both.)

111. There was tubercular disease in my wife's family, although she died of pneumonia. My children were raised by the bottle, yet they and my grandchildren are very healthy. (Fredericktown. Both.)

114. My practice is almost entirely in the country, with very few cases of tubercular disease, and those chiefly in adults. We have no large herds of cattle, and comparatively very few bottle-fed infants. I am fully satisfied of the communicability of the disease from individual to individual, from instances within my knowledge. (Webster. Country.)

115. Practice exclusively in the country. Have had no experience with infantile tubercular disease. (Hepburn. Country.)

120. (7) I do not believe tuberculosis to be contagious. In 50 years' practice of medicine I have seen several families where the mother died with consumption after having had five or six children; they living to maturity without showing any signs of it. Some of the mothers had it when pregnant. I have known of persons dying from it when not a trace of the disease could be traced in the most distant relative. In one instance the father died from it; three of his sons died from it about maturity, but none of the daughters ever had it. In other instances the husband or wife died from it, the one left never taking it. I believe there may be a predisposition in some persons to take the disease from neglected colds. (Gibsons. Country.)

123. (2) Yes, but most of them die the first year from indigestion. (5) I have not known of any bovine tuberculosis in this (Darke) county in 27 years. (6) Not to be sure of. We have no autopsies in this county. (New Weston. Country.)

124. (2) No, unless acute indigestion and meningeal affections are tubercular in origin. (4) Those fed with mixed milk were much more liable to the above affections than those fed from milk of selected single cows. (Leesburg. Country.)

125. (5) Yes, in cases where parents and relatives were healthy and no tuberculous visitors or attendants could account for it. (Elyria. Both.)

128. Mr. E—— died, so I was told, of consumption of the lungs. Mrs. E—— gave birth to a child near the time of the father's death. About ten or twelve months after the birth I was called to treat the child. There was cough, emaciation and other tubercular symptoms. After a continuous treatment for some eighteen months or longer it became a hearty boy and now, at 4½ years, is quite hearty. There is no history of tuberculosis in the family of which Mrs. E—— is a member, and the only way I could account for the little one's malady was, that it was phthisis, derived from the father and not from the nursed mother, who shows no signs of having any dyscrasy. We have few bottle-fed infants here; probably not one in fifty. (Addison. Country.)

129. Thirty years' country practice leads me to think there are very few such cases in a healthy country, where the water is good. (Delta. Country.)

131. (5) I have had no reason to suspect it in any particular case but I believe it often occurs. (7) I have observed cases in adults contracted from a tuberculous attendant. (8) I have observed a number of cases in infants and adults in houses previously occupied by tuberculous persons. (Cincinnati. City.)

134. I believe that milk and meat are carriers of the germs, notwithstanding that I have been unable to identify them as causes in any one case. (Huntington. Country.)

137. I have believed for over thirty years that tuberculosis was infectious, and the child is more liable to be infected from a tuberculous mother's breath or a kiss than from her milk. (Shiloh. Both.)

138. I have never heard of cows in this locality being troubled with tubercular tendency as they seem to be in some places. (Greenspring. Country.)

142. I have seen three cases of tuberculosis in infants (bottle-fed) whose mothers died of tuberculosis. One died before the mother, with pulmonary tuberculosis; one three months after the mother, with tubercular meningitis and the third recovered after its mother's death and upon changing homes. This, of course, does not touch upon bovine infection. I am at present physician to the Shelby County Children's Home, and have been impressed with the small amount of infection at this and other homes. (Sidney. City)

143. (5) Yes, in the case of the mother having a tubercular diathesis. (7) In one case. In another there was probable heredity. (Rushsylvania. Country.)

146. I live in a neighborhood where there is but little tuberculosis, especially among children. I have in mind one case, an infant which died from tuberculosis,

having taken it from the mother, (she died about two months before the child) and in all the other cases which I have waited upon, as far as I could tell, heredity played an important part. (Stevideo. Country.)

148. In a practice of ten years I have never had a case of infantile tuberculosis. (Union Furnace. Country.)

149. (4) I prefer mixed milk of large herds and always have the milk well sterilized. (5) I think not; heredity or some acute disease seems to precede infection, although in some cases no predisposing cause was apparent. (7-8) Cannot say, but as a rule the surroundings were not as healthy as they should be. (9) No. I think the reason for this is that children do not expectorate and are less liable to the pulmonary form of tuberculosis. (Cleveland. City.)

153. (2) While I have never had a bottle-fed infant develop tuberculosis, I believe that generally they are more fit subjects for its development than the average breast-fed infant. I have noticed that infants throve or the reverse, in proportion to the manner in which the milk is prepared. In intelligent families, where care is taken, usually a bottle-fed infant does as well as a breast-fed one; but when the milk is carelessly prepared the child does not do well. (5) While I have never been able to trace tuberculosis in bottle-fed infants to the milk supply, I believe it to be a source of the disease. (Columbus. City.)

155. (9) Yes, the same bacillus is present, and affects the predisposed, young and old alike. (Steubenville. City.)

156. I had a patient last spring; married lady; no children; no tuberculosis on either side of family, who contracted the disease by dressing, laying out and removing bedding of a neighbor lady that died of tuberculosis. She carried out the sodden bed ticks and bedding right in front of her face. I did not attend the lady who died first. Neighbors say she expectorated over bed and floor. In the second case the diagnosis was confirmed by post-mortem. (Rushville. Country.)

159. (2) I am satisfied that more than once I have seen bottle-fed children sick with tubercular disease, but I never saw a tuberculous child breast-fed by a healthy mother. (3) I recall two or three cases in which I had reason to suspect the milk supply, but cannot give definite particulars. (4) I have noticed that children fed from one cow only are more apt to be sick than when fed from several cows. (5) I never noticed tuberculosis in children as caused by the meat supply, but rather from lack of meat; I am convinced that tuberculosis is a contagious disease, to a considerable extent. I have had some practice among the negroes, and they are notorious disseminators of tuberculosis. (Beaver. Country.)

161. In this blue grass region I have been in favor of bottle-feeding, because of the possibility of procuring milk from healthy cows; but have advised keeping away from herds and from cows closely stabled, for winter use. (London. City.)

162. My active practice ceased eleven years ago, before the recent investigations as to tubercle bacillus. Experience taught me that bottle-fed infants, under old methods, were more liable to tubercular affections, especially tubercular meningitis and scrofula. (Chillicothe.)

164. I believe the disease is contagious, not inherited, and that a house occupied by a tuberculous person is a source of contagion to younger persons. (Toledo. Both.)

165. I can recall but one case of pulmonary tuberculosis in an infant. This was breast-fed and since the child's death several aunts have died with tuberculosis. I have seen some 10 or 15 infants die from tubercular meningitis, when they were breast-fed, but can give no information as to antecedents or house in which they lived. One family living in a brick house had the mother to die of tuberculosis. No precautions were taken as to sputum. A daughter died some two years later

of the same disease. Immediately after the second death I had the entire house disinfected with formaldehide. This was three years ago. The husband and two children are in perfect health at this time. I have seen no case of bovine tuberculosis, nor of human tuberculosis contracted from this source. My attention, however, has not been especially directed to this form of investigation in case of my patients. (New Paris. Both.)

166. (2) Too many do not live long enough to develop tubercular disease. (5) City pork-eaters are more prone to tubercular disease than those who abstain. (Zanesville. City.)

178. There seems to be little or no tubercular disease in this section. (West Carrollton. Country.)

185. We have a family that presents quite an interesting history, which is as follows: The parents have always been strong people and are living. They had ten children, all stout and hearty. The eldest child (daughter) married and went from home, and has never shown any tendency to tubercular disease. The next in age (son) married and within a year from day of marriage the wife began to show signs of tubercular lung trouble. She gave birth to a babe, grew steadily worse and died. Within two years the husband and babe were dead with tuberculosis of the lungs. The disease has continued its work in the family until now there remain four out of a family of ten children. They have all died between the ages of 18 and 28 years except the above mentioned babe, which was less than two years old. The eldest and the youngest three children are in poor health. It is probable that the others contracted the disease from the son's wife, which he brought into the family. (Crisp. Country.)

186. I believe that a large percentage of tubercular trouble in infants may be traced to the milk supply of artificially fed infants. I congratulate you on the work you are doing, and hope you may be able to point out clearly to the profession their duty in observing more closely the results of feeding infants from cow's milk. (Mansfield. City.)

188. I have become so thoroughly convinced of the danger to infants from feeding cow's milk that I invariably insist on the use of some other food, preferably malted milk. (Mason. Country.)

190. Regarding question 8: Almost directly opposite my house stands an old dwelling in which two deaths from consumption have occurred since 1873. It has been occupied by several families (renters) several years since the deaths took place. No efforts at disinfection were made. Healthy children have been born and reared in it without the slightest indication of infection to any of its occupants, old or young, so far as tuberculosis goes. I know another house in this village which was used as a dwelling by a family consisting of father, mother and four sons; the father was of tubercular stock; he died of the disease as did the four boys. The mother who lived four years in an atmosphere saturated with the sputa, etc., stands alone to-day, probably because she was not cursed with the same evil inheritance. (Sugar Grove. Country.)

194. In a practice of 25 years I have seen but three cases of what might be called tuberculosis in children under two years of age. Two were tubercular meningitis and the other tabes mesenterica. All were from consumptive ancestry. I do not know whether they were fed from the bottle or the breast. My own experience is that tuberculosis is a very rare disease in infants. The only case of consumption in a grown person that I had reason to believe was propagated by contagion came from sleeping on a feather bed that had previously been slept on by a consumptive person. (McConnellsville. Both.)

195. Case 1: Child died of tubercular meningitis; father tuberculous. Case 2: Mother tuberculous, died when child was an infant. Child died at four years;

tubercular meningitis; bottle-fed, but have no knowledge of cause. Case 3: Child died of acute tuberculosis, following pneumonia; house a hot-bed of tuberculosis, several members of a family having died in it before this family moved into it. In my practice I have not had much experience with bottle-fed infants. (Qualey. Country.)

200. (5) A woman 40 years of age, who had been using the milk of a tuberculous cow, developed and died with tubercular peritonitis. (Louisville. Country.)

203. I have been a careful observer of tubercular troubles and conditions for the last thirty-five years. The position I occupy at the present time is more from what I have learned in treating and observing cases which finally terminated unmistakably in tubercular fatality than from anything I have ever read; and each day and each case gives me no good reason for changing my basis. If the vital force is perfect tubercular disease cannot be transmitted, either by contagion or by heredity; but if the vital force of any animal, including the human, is weakened in a certain relation to nutrition, tuberculosis will supervene, whether the parents have it or not or whether there be contact with any infectious substance. I am ready to accept much more than has ever been claimed for the tuberculin test and treatment, for it deals with conditions never accredited to its action on the living organism. The parasite is the product of, and not the cause of tubercular conditions or diseases. (Akron. Both.)

204. (3) No, and I believe the claims in this direction are grossly exaggerated. (5) No, or very doubtful; probably more meat than milk, and other diseases more often than tuberculosis. (9) No, nor as a rule is tuberculosis communicated from patient to other members of family. In 1900 cases less than 2 percent could be claimed as of this character. (Mt. Vernon. City.)

214. While my experience has not been of much value in determining that infected food is a source of danger, I firmly believe that it is. (Lebanon. City.)

217. (2) In this section there are very few bottle-fed infants. (5) Most cases are hereditary, with me. (9) Yes, because I believe the germ can be inhaled, and if the condition of the system is right for its reception and propagation tuberculosis will follow. (Mentor. Country.)

218. (2) No. More at breast. I have found marked cases of tabes mesenterica and one of tubercular abscess following the nursing a tubercular mother, in child 18 months of age. May the Ohio Agricultural Station push this good work. (Alliance. City.)

221. I have had several cases of tuberculosis under my charge but in no case have I been able to trace the disease to bovine origin. (Carey. Both.)

222. I have found children fed from herd milk subject to disease of the bowels, or tabes mesenterica. In my opinion tuberculosis is contagious only when the strictest sanitary measures are not carried out. The expectorations should be collected on cloths and burned and other sanitary measures should be observed. (Weston. Country.)

227. I regret that I cannot aid you in your laudable research, the facts are as you state but I cannot furnish the proofs. (Springfield. City.)

229. (2) No, only to gastro-intestinal trouble. (8) I have found several houses to have successive tenants become tuberculous. (Marietta. City.)

230. (5) Some cases do occur in families apparently not tuberculous. (Akron. City.)

231. (9) Only one instance in fifty-two years. (Tiffin. City.)

237. (2) They are more subject to stomach and bowel troubles, but whether to tubercular disease I do not know. (Lemoyne. Country.)

238. (3) One suspected case of tubercular meningitis, but was unable to confirm by autopsy. Child nearly two years old. (Cheshire. Country.)

240. While I find but little opportunity to trace out the causes of tuberculosis I find that it is most prevalent in houses that have been long inhabited in older parts of town. All the evidence seems to me to indicate that tuberculosis is contracted by contagion or by consumption of infected food, and not by heredity. Nothing seems more reasonable to me than that milk from tubercular cows would transmit the disease to children. The inspection of cows with regard to tuberculosis would be hailed with approval by the medical profession. (Springfield. City.)

244. (2) Have had no cases in children when it was possible to tell that the bowel lesions were tubercular. (6) I have never seen tuberculosis in a child at the breast, although I can recall several cases of children who must have died of meningitis, most likely tubercular, and whose mothers afterward died of pulmonary tuberculosis. (Cincinnati. City.)

246. My practice is entirely in the country. The number of bottle-fed infants is very small. I cannot now recall a single case of infantile tuberculosis that could not be traced to hereditary taint from one or both parents or grandparents. (Beverly. Country.)

247. I have practiced medicine for 38 years, and during that time I have never seen a case of tuberculosis in an infant that was not the offspring of a consumptive parent, either father, mother or grandparent. I have frequently seen cases of bowel complaints, diarrhœa, etc., in bottle-fed infants that were plainly the effects of malnutrition and indigestion. From my experience I have no faith in diseases being contracted from the food except in typhoid fever, cholera and a few others, and then only when the stomach is "out of tune," or off its guard. — As boiled milk is easier digested than raw, it would be a good plan, in my opinion, to recommend that all milk intended for food for children should be boiled. I do not believe that tuberculosis is inherited, but I believe that the disposition towards the disease is inherited. (Clarington. Country.)

250. (2) Yes, much more. I have many times been obliged to get milk from another cow and sometimes to dispense with the cow altogether; but such cases usually arise from inanition or lack of ability to assimilate. (So. Bloomfield. Country.)

251. I feel that the answers I have given to your questions need a little explanation. — My practice is confined to three islands, Put-in-Bay, Middle and North Bass. The farmers here (for it is a country practice) are all small-fruit farmers. Very few keep more than one cow and, generally speaking, she has the very best care, clean and wholesome food and a clean and well ventilated stall to be kept in at night. Keeping but one cow they endeavor to have a good one, usually a half or three-quarter-blood Jersey, so you see when I am compelled to feed babies cow's milk, I have what very few physicians have, and I have always appreciated it, and think it has modified my answers to you very much. My tubercular cases have, so far, had a tubercular history of two or more generations. (9) A babe's mother, grandmother and great-grandmother, according to the best history of the cases I could get, had all died from consumption. The father, a perfectly healthy man and with no tubercular history for three generations, at least, would allow no one to nurse the child but himself. I was utterly unable to make him believe that he could contract the disease from his child. He nursed the child about 17 months when it died. During this time he developed a cough and it was followed by the usual symptoms, and about one year later he died with acute tuberculosis. So you can see surroundings shade my answers. (Put-in-Bay. Country.)

252. (6) In one case, and in that case the mother was of lymphatic temperament. (9) I have never found such a case, yet I am confident it might happen.

I believe that consumption may be inherited and that it is also contagious. (Rural Dale. Country.)

253. (6) Yes, two cases. (7) In one case, yes; the other had family history of tubercle. (8) I have had several "coincidences" of this kind and believe in rigid disinfection of such houses. (9) Never saw a case that could be traced; the reverse has fallen under my observation.

254. (4) All cases noted fed from single cows. (7) There were also in some cases tuberculosis attendants and visitors. (Lebanon. Both.)

261. (2) I have not, although they are more subject to many diseases, and tuberculosis of intestines may have been overlooked. (5) No, though I admit that such origin is probable. Often, too, the disease may come from tuberculous persons handling milk and butter. I believe that all are exposed to tuberculosis; that it is a question of susceptibility. With half the human race infected to some degree there is hardly complete escape from its contagion; yet it should be controlled in every way possible. (New Lexington. Both.)

263. There is only one family in my neighborhood in which tubercular disease has developed. The family is German; father healthy, 68 years of age; no signs of the disease in his family. Mother died at age of 52, from cancer of the womb. One boy died at insane hospital — tuberculous; two boys died at home, pronounced cases; one boy hung himself; there was no doubt but that he was slightly deranged; post-mortem showed right lung somewhat affected; two girls, married, died at home, clear cases of tuberculosis; two girls are still at home but are not strong. One girl is married; the first child, a boy, nursed, is not healthy. No tubercular disease on father's side. I ordered the next child (girl) to be fed from a selected cow, never permitting it to be nursed. It is now 13 months old, strong and healthy, and has not the sickly appearance of the boy. (Harris. Country.)

264. (4) I have had two cases where I believed that infants had been infected by changing from milk of single cows to that of herds. (6) I have observed four cases in which children had tubercular diseases while the mothers remained uninfected for years and are still healthy. (7) In these cases the father or some one else was tuberculous. (9) In one case I believe it was communicated in that manner. (Paulding. Both.)

265. Owing to the inadequate facilities for making bacteriological observations in the country it is impossible to make correct answers to most of these questions; but it is my opinion, supported by a limited experience, that the vast majority of tubercular infections occur from contaminated public houses and residences. Direct infection from ulcer to healthy abraded surfaces occurs easily and frequently; and if the cause of bovine tuberculosis is the precise bacillus of the human variety there is no reason why milk from a tubercular udder ought not to produce tubercular enteritis in the user. To the end that the statistics be trustworthy I would suggest that an effort be made to establish state bacteriological laboratories at convenient intervals over the state for the elucidation of just such problems. (Newton Falls. Country.)

266. I have just lost a patient (young man) from consumption. He was sick five months, passing into my care three weeks before death. During my attendance on him I became aware that the expectorations were emptied into the garbage barrel, where they were taken to be fed to cows and hogs by the public garbage collector. (Toledo. City.)

269. Believing tuberculosis to be contagious we are at all times and in all cases on our guard against sources of contagion and we do not average one case of tuberculosis a year in this thickly populated township. (Bellbrook. Country.)

271. (2) Bottle-fed children are more subject to all diseases than those

nourished at the breast by a healthy woman. (3) I believe so, but cannot give particulars. (4) My preference has been for mixed milk of large herds, as being more constant in composition. (5) I believe that tuberculosis may be due to milk or meat supply, but have not been able to demonstrate the connection. (9) I have seen no positive demonstration, but believe it possible. (Cincinnati. City.)

272. (3) I have had five or six tuberculous children that were fed on cow's milk and I could see no other cause for the disease, but no examination of the milk was made. (9) Yes, several such cases. (Columbus. City.)

275. My practice of 25 years has been favored by not coming in contact with cases such as you refer to. (Colebrook. Country.)

276. Nearly all the cases of tuberculosis in a practice of 30 years have been young unmarried persons. It is notorious that farmers drink less milk than people living in villages and cities. (Norwich. Both.)

282. In my experience the bottle-fed infants which die usually die of cholera infantum (acute) or of inanition from gastro-intestinal catarrh, due to overfeeding. I never had a case of tubercular trouble in an infant in which the tendency was not traceable to heredity. (Leipsic. Country.)

284. (2) There are relatively fewer bottle-fed infants in the country than in the city. It has been my experience that children fed on the bottle are more susceptible to tuberculosis than breast-fed children, but whether because they contract the disease from the milk or are less able to resist the virus I am not able to say positively. (5) It has been my opinion that some older children and adults contract the disease from meat, but more from contagion. (6) I have observed three cases of this disease in infants when parents were free and had no family history of tuberculosis. (7) I attributed the cause of two cases to a visiting relative who was in the habit of kissing both children frequently. (Peninsula. Country.)

285. I have not had a case of tuberculosis in a young child in 7 years' practice. (Kimbolton. Country.)

287. (4) When milk has been changed often or taken from different cows the greatest changes were noticed and the mortality increased. (Waterville. Country.)

289. I have had two infants which were never, to my knowledge, surrounded by tubercular people, but who certainly had tubercular enteritis, and I inferred that it was due to ingesting diseased milk; yet the cows appeared to be healthy. I have had two boys and one girl, in different families, no relationship, aged from 6 to 12 years, develop coxalgia (tubercular ostitis), yet there was no tubercular family history, as far back as we could reach. In all three of these families the cows did not have the best of care; their hair looked rough and dull in color, showing that they were not well nourished at least, and from appearances I inferred that they might have been the cause of the trouble. However, it is my conviction that children often contract this most dreadful disease, in some form, in the school room. (Quaker City. Country.)

291. My father inherited consumption from his mother and his children have all died with it except one brother, who has it, and myself. My wife's mother and two other members of her family have died with it. Our two children were raised on Jersey milk from fresh cows, well and carefully fed, the milk at first being diluted one-third with water and sweetened with milk sugar. These children at 18 and 12 years of age are hale and hearty and show no tendency to tuberculosis, so that my experience has been that milk properly prepared will not injure children but greatly benefit them. That tuberculosis is hereditary there can be no doubt, for it has been fully demonstrated. So far as contagion is concerned I think the only danger would be by inoculation, in some way coming in contact with the tuberculous matter. (Tiffin. City.)

299. I have had two decided cases of communication from adult to adult, but in 20 years' practice have had no case of tuberculosis under 15 years of age. I have had a few bottle-fed infants, but used prepared food chiefly. (Rogers. Country.)

301. (3) Not positively. Cases of pre-phthisis are more common in milk drinkers. (5) Meningitis; boy, 14; farmer; used meat and milk; no other probable source; fatal: several similar. Hip joint, intestinal and pulmonary tuberculosis and kidney tuberculosis observed in adults and children in healthy country homes without other apparent cause. Pre-phthisis is very common, more so among milk drinkers and meat eaters I think. (Tallmadge. Country.)

304. (3 and 5) Theoretically I believe tuberculosis can be communicated in that way, but I have met with no instance of the kind; in every case of tuberculosis in bottle-fed infants I have been called upon to treat I found evidence to convince me that the disease had been communicated from another person. (6) Yes, three instances, in all of which I believe the infants contracted the disease from their fathers who had it. (8) I have had one case of tuberculosis in adult where there had been the death of a consumptive in the same house about two years and a half before. Another case came under my notice — a servant girl who acquired the disease while working for a lady who had it in its last stage. (Dowling. Both.)

306. In this vicinity there have been no large herds of cows until the last six years, and the milk from them goes to the creameries. J—— H—— died with consumption of the lungs, but his wife and child show no signs of it, fifteen years after his death. (Croton. Country.)

315. We have very little tubercular trouble among children. (Marathon. Country.)

317. (3) A child 17 months old when I first saw him; had been fed on cow's milk; child rickety; tubercular; no hereditary tendency; second child; parents and brother healthy; believe it to be due to tubercular milk. (Cleveland. City.)

318. I have one case of pulmonary disease in young woman, supposed to have been contracted from a pet cat. (Zanesville. Both.)

319. (2) Yes, but a sick mother is a frequent cause for bottle feeding. (5) I have suspected it but could not demonstrate it. (7) Probably, as such persons, not being able to work much, are often general and frequent visitors. (9) Yes, and from adults to infants. Communication is, in my opinion, a larger factor than inheritance. (Ridgeway. Country.)

322. (2) No; less, if such bottle-fed infants have their milk sterilized by heat. (6) In one instance, where the grandmother was tuberculous and was much with the infant. (8) Impossible to determine, usually, as tuberculosis often exists without suspicion or proof. (Cleveland. City.)

324. (5) I have never considered it worth while to attempt any investigations, because we do not know a tuberculous cow from a perfectly healthy one without the tuberculin test. (West Jefferson. Country.)

325. (2) Yes, provided mothers are non-tuberculous. (3) Not directly, but milk from such cows is necessarily a pre-disposing cause. (5) No, partly because as country children grow older they drink less milk. (6) No, except where father was tuberculous. While there is, no doubt, direct tubercular contagion through the medium of milk of diseased cows, the number of cases in children must be small, compared to those that develop tuberculosis while being poorly nourished on exclusive use of milk from old and underfed cows, and especially those that have not been fresh for a year or more. In rare instances I have known cows too old to breed to be milked for a period of 2 or 3 years. Milk from such, like mother's milk after the first year of nursing, is exceedingly

poor in quality and may be a powerful predisposing cause of tuberculosis. Milk from diseased mammary glands of the mother, or udder of the cow, is an important factor in the induction of tuberculosis, often overlooked. How many large herds of cows can be found in which none can be found that give occasionally "ropy" milk? Such milk will surely induce malnutrition — a constant factor in all tubercular diseases. I never allow a child to nurse a breast that has at any time been abscessed if I can prevent it, but many a child receives milk from udders, the former seat of abscess. Such milk, if well boiled (not pasteurized) might produce a toxic effect, but never infection. All dairies should be inspected, whether or not the cows are "tested," as it would weed out the old and infirm animals. (Washington C. H. Country.)

327. (2) I believe it is seldom that the death of a child from tubercular disease is observed in the country, but we know that among bottle-fed infants there is greater mortality, due to deranged digestion, than among those who are nursed by the mother. (West Farmington. Country.)

328. (9) More from adults to infants; and some very plain cases of this; also some clear cases from one adult to another and some almost certain cases from vaccination. (Middlefield. Country.)

329. My practice of seven years has been confined to this one community and I have found but one case of infantile tuberculosis, that being as nearly hereditary as the disease can be. The adult cases have also had hereditary predisposition. (So. Lebanon. Country.)

330. My practice is entirely in the country and in the eleven years that I have been here I have met but three cases of tuberculosis, all adults, 25 to 40 years of age. One came here in an advanced stage and died here; the others I sent to Colorado and New Mexico and reports from both are favorable. It has not been possible to trace the disease to its origin in either case. (Kinsman. Country.)

331. There are very few cases of tubercular disease here. I have known of but three or four cases in five years. (Perry. Country.)

332. (4) In an observation extending over forty years I have never known a case of tuberculosis, the origin of which could not be traced to other causes than those named. (7) I have known the attendant to become a victim to tuberculosis. (Emery. Country.)

333. (3) Yes, in two cases we believe without doubt. (5) Yes, in both. (8) Not that we could establish. (9) In one case we could trace the disease to no other source. (Milford. Both.)

334. (2) No, because I always feed sterilized milk. (5) I have not had a case that I could trace definitely to either of these causes. (6) I do not think I have, but would not be certain. (7) When probably the father only was infected. (8) I have seen a case in an adult which I believed to have had this origin. (9) No, but believe that it might readily happen. I have seen three cases of pulmonary tuberculosis follow in rapid succession in the same family. (Madisonville. City.)

338. In treating children with tubercular mothers I have always fed some of the prepared foods or sterilized milk. I have lost a few tubercular babies in hereditary cases only. (Cleveland. City.)

339. My practice has been principally among the farmers of Champaign, Logan and Union counties, for forty-two years. I do not remember a single case of tubercular disease among children that I could reasonably attribute to milk or meat supply. I have always looked upon good, fresh, country milk as an ideal food for babies when there was any reason for the mother not nourishing them. Two children in one family contracted tuberculosis of lungs by sleeping with a tuberculous friend and visitor to the family. No other member of the

family ever developed the disease. In one case a young girl of non-tuberculous family developed the disease within three months after moving into a house where two persons had died within a year, in the room occupied by my patient.

As was to be expected the answers to our inquiries show a wide diversity of experience, representing, as they do, all conditions of life, from those found in the most sparsely settled country districts to those in our largest cities; and in considering the results we must bear in mind that the very nature of the case precludes the possibility of absolute demonstration. As was said in the preliminary bulletin, accompanying this circular of inquiry:

"The agricultural experiment stations, which are now world-wide in their operations, are pushing this investigation from the biological and veterinary sides; but there remains a field which neither the biologist nor the veterinarian can exploit — the field of human experience. We cannot take infants and children and experiment on them as we do on guinea pigs and calves, nor can we get under personal observation a sufficient number of the accidental experiments which humanity is blindly making to settle definitely the points in question. These experiments are being made every day under the very eyes of the ten thousand physicians in Ohio, and they, by taking up the third side of the problem, in the light which never before the present decade has shone upon it, may round out and complete the work; but without such help it cannot be done."

This appeal was made with great hesitancy, for it has been my observation that our physicians are the hardest worked, and often the most inadequately paid members of the community. Under the circumstances existing it was not possible to furnish even so much as the return postage for the information asked, the only compensation that could be offered being the possible value to the community at large of the results of the inquiry. Under these circumstances a special acknowledgment is due to the large number of physicians who have so kindly replied to the inquiry.

It will be observed that the country practitioners make frequent reference to the comparative fewness of bottle-fed infants in the country and also to the rarity of tubercular disease among country infants, several stating that they have never seen any cases of infantile tuberculosis in the country. The veterinarians make similar reports respecting the prevalence of bovine tuberculosis in the country. With occasional exceptions it is practically unknown, except in the vicinity of the larger cities. But the statistics show that there are more deaths in Ohio from tubercular diseases in infants under one year of age than at any other age-year of life, and since so few of these are found in the country we must conclude that the great majority of these cases occur in the cities, a conclusion which is confirmed by the statistics of the census.

Of course it does not necessarily follow that the excess of infantile tuberculosis in cities is altogether due to the larger proportion there of bottle-fed infants, nor to the greater prevalence of bovine tuberculosis in

the dairies from which much of the food of these infants is drawn. The statistics show that the deaths from tubercular disease at all ages are relatively more numerous in the city than in the country. How much of this excess in cities is due to contaminated food supply, and how much to greater exposure to other sources of infection, cannot be known, but the fact that tuberculosis of children has been traced so directly to tuberculous milk, fully justifies the inference that such milk may be an important factor in the infantile death rate of cities.

Both classes of physicians agree that there is no food for the babe so wholesome as that from the breast of a healthy mother, and there is also a general agreement that the bottle is the safer source of food supply if the mother be tuberculous.

While comparatively few report that they have been able to trace the origin of tubercular disease, either in infants or older persons, to the meat or milk of tuberculous animals, yet there are enough of such reports to justify all the vigilance that can be exercised to avoid such infection. In considering this point we must remember the exceeding slowness with which tubercular infection often, if not usually, takes place, in consequence of which it would, in most cases, be practically impossible to trace such infection to its exact source, even if the most extreme views were accepted regarding the danger of infection from the food supply. This is especially true of the cities, where so little is or can be known of the sources of such supply. Our experiments are fully corroborative of thousands of others in showing that an animal may be infected with tubercular disease for many months before any external symptoms become manifest, and we have no reason to doubt that the same is true of the human subject. For this reason, the source of infection would, in most cases, be completely lost sight of long before its symptoms became manifest.

The answers to the fourth question are largely colored by circumstances. Only the wealthy family can keep a single cow under normal conditions in the city, while the attempt to procure the milk from such a cow kept outside the city must be attended with much uncertainty; hence the city practitioner rightly prefers mixed milk; but in the country there are few large herds, and the farmer has the best opportunity for selecting and caring for a single cow in such manner as to attain the best results, a point well brought out in reply No. 251, and so we find that physicians in the country very generally prefer the milk from single cows, although there are exceptions in both cases.

THE HEREDITY OF TUBERCULOSIS.

Questions 6, 7 and 8 were designed to bring out observations bearing upon the problems of heredity and contagion or infection in tubercular disease, and the answers given are worthy of the most careful study. Of those who have observed instances of tubercular disease in infants breast-

fed by tubercular mothers, many add remarks indicating that they are very unusual. "One case", "one or two cases", "a few cases", are expressions recurring repeatedly in their reports. Some of those who reply to questions 7 and 8 in the negative add remarks indicating disbelief in the contagiousness of the disease, while many of the doubtful replies show that attention had not previously been drawn to those possible sources of infection.

When we consider these replies in connection with the statements of many of the physicians having country practice, that they have met few or no cases of infantile tuberculosis of any sort, even in a practice of many years, we must conclude that *infantile tuberculosis is an extremely rare disease, except where there is a tuberculous environment.* This is a most important point. We have been assuming that because the children of tuberculous parents are so often tuberculous, therefore tuberculosis is a hereditary disease; but we would not think of calling measles and smallpox hereditary diseases on the same kind of evidence.

The fact that entire families are swept away by this scourge, and that it reappears in generation after generation of the same blood, are quite as easily explained by the theory of contagion and infection as by that of heredity. Under no possible conditions could the opportunity for communication of disease from person to person, and especially from parent to child, be greater than under those of the family, especially when watchfulness against such communication has been relaxed because of belief that the disease is only hereditary and never contagious. And when we consider the insidious onset and the slow course of the disease, and the great length of time through which the germs of other diseases are known to retain their vitality, we can readily understand how tuberculosis may pass from generation to generation, and how infected houses may carry the infection to later tenants, perhaps of the same family, perhaps of others; perhaps those immediately following, perhaps not until years afterward, when some long undisturbed deposit of infectious matter has been freshly stirred up.

The cases in which members of a family escape the infection, while others fall victims to it under apparently no greater exposure, are paralled by similar cases of immunity in all contagious diseases, both among men and animals. Some individuals appear to be immune to certain diseases throughout life, while others escape at one period of life only to be taken at another. In fact, all experience indicates that the healthy human system will generally resist the tubercular infection until way has been made for it by some other disease. A severe cold, for instance, may leave a plowed and harrowed field in the pharyngeal or bronchial glands, in which the germs of the tubercle bacillus find a congenial lodging place.

In short it would seem much easier to formulate a cohesive and rational theory of the propagation of tubercular disease by infection than to account for it by heredity; and while I would not be understood as deny-

ing the possibility of a hereditary tendency, making the individual more liable to the tubercular infection, it does not seem that such a theory is at all necessary to account for the phenomena exhibited by tuberculosis, if we but take into consideration all the factors bearing upon the problem.

In discussing the question of heredity we should keep clearly in mind the biological meaning of the term. The fact that the child of tuberculous parents develops tuberculosis, is by no means conclusive evidence that it has inherited the disease in the sense that it may have inherited physical conformation or mental characteristics. The experience at this Station with tuberculosis in swine, given on another page, gives a forcible illustration of the manner in which the disease may even skip a generation, to reappear in full force in the next and yet not come under the law of heredity, as above defined. Again, there is a possibility of pre-natal infection from either parent, previously referred to, which would be quite a different matter from constitutional heredity.

It is true that either of these forms of transmission of the disease given would be in one sense a hereditary transmission, but it would be transmission of infective material, not of actual disease nor of diathesis. The difference may at first sight appear to be one of hair-splitting; but in fact this difference is of fundamental importance, because there can be no hope of overcoming this dread scourge until the fatalistic idea that it is a constitutional disease can be displaced by a clear conception of its contagious character.

It is the province of the agricultural experiment station to learn and demonstrate facts, rather than to formulate theories, and to deal with questions pertaining to agriculture, rather than those of general hygiene. The study of the diseases of animals, however, is explicitly enjoined upon these stations, and the problem of tuberculosis in animals is so intricate, and withal so closely interwoven with that of the same disease in the human subject, that all the light is needed that can be obtained by the joint study of the disease in both classes of subjects.

It is safe to say that in the experiment stations, and among those who have had the widest opportunity for studying tuberculosis in animals, there is no longer a shadow of doubt as to its contagious character; and that if the war against this disease is to be successfully waged it must be along this line. Therefore it is of first importance that the farmer and cattle breeder should be shown the grounds upon which this belief in contagion is based, and should have their eyes opened to the possible explanation of human tubercular disease on the same grounds.

On one point we may be sure, whether dealing with animals or men, and that is that we can be led into no fatal or injurious mistake by accepting and strictly acting upon the theory of contagion. The destruction of the sputa of the consumptive, the utmost cleanliness in rooms and clothing, the avoidance of every possible means by which the disease may be com-

municated can do no harm in the case of the human subject, and abundant evidence has been accumulated to show that it may do much good.

In comparing the contagion of tuberculosis with that of measles and smallpox I would not be understood as claiming equal facility of propagation. On the contrary, it is not believed that the tubercle bacillus is usually, if ever, carried by the breath, or that it ever floats in the air, except when temporarily stirred up, as in sweeping. In the examination of milk for this organism it is found most frequently in the slime of the separator and in the heavier parts of the milk, and but seldom in the cream, thus showing that its specific gravity is greater than that of milk. It is believed that the sputum is practically the only vehicle by which the infection is carried. It follows, therefore, that *with proper care* the consumptive is not necessarily a source of contagion.

Regarding infant mortality from tubercular disease some interesting statistics are given by G. Sims Woodhead, M. D., in the *Practitoner* for June, 1898, who quotes from investigations by Bolitz on the statistics of post mortem examinations of 2, 576 children, who died in Kiel during the years 1873-1889, and in whom were found the following percentages of tuberculosis to the total mortality at each of the different ages:

Sitll-born children	0.0	per cent.	Up to 2-3 years old	33.0	per cent.
Up to 4 weeks old	0.0	"	" " 3-4 " "	29.6	"
" " 5-10 weeks old	0.9	"	" " 4-5 " "	31.8	"
" " 3-5 months old	8.6	"	" " 5-10 " "	34.3	"
" " 6-12 " "	18.3	"	" "10-15 " "	30.1	"
" " 1-2 years old	26.8	"			

It appears from this table that there was no evidence found of tubercular disease among stillborn infants and those which died during the first weeks of life, but that the percentage of deaths from such disease was relatively uniform from the second year onward. These statistics are in harmony with our knowledge of túberculosis in cattle, but they seem to be at variance with the statistics shown by the census and tabulated on page 344, in that they show a larger relative death rate from tubercular disease during childhood than is shown by our statistics. Three points must be considered here, however, namely: (1) European statistics and general statistics show that tubercular disease is much more prevalent in Europe than in America; (2) the statistics just given are those of a large city, whereas the population furnishing the statistics of our census was one-half rural, and the evidence shows that rural districts are relatively free from tubercular diseases, and (3) they are statistics derived from post mortem examination, whereas those of our census are chiefly made up from ante-mortem diagnosis only, and there is reason to believe that this is often defective, especially in those forms of tubercular disease to which children are especially subject. Says A. K. Chalmers, M. D., of Glasgow, in the journal just quoted:

"Indeed, every post-mortem room affords ample testimony that tuberculosis in children is more common than is usually supposed, and that many of the chronic diarrhœas and broncho-pneumonias are in reality of this character."

In this connection I quote from a report in the *Standard* the statement by Sir Richard Thorne, a member of the Royal Commission on tuberculosis, that whereas there has been an immense reduction in the death-rate from many forms of tuberculosis, notably phthisis, yet when we examine the death-rate from *Tabes mesenterica*, a form of tuberculosis in which the infection is received into the alimentary canal instead of the lungs, it is not only found that the gain attained at other ages has been lost in the case of children and infants, but that, in addition to this, there has been a very heavy increase of deaths from this cause, under one year of age. This increase, says the authority quoted, has gone hand in hand with a steady increase in the consumption of cow's milk as a food in England.

IS CONSUMPTION DECREASING?

Mortuary statistics of consumption indicate a decrease in the death rate from that disease during recent years, both in the United States and in several European countries, and this fact has been brought forward as an argument against the theory that bovine tuberculosis, which is apparently on the increase, is identical with human consumption. In this connection the following table, showing for Ohio, exclusive of Hamilton county,[30] the total number of deaths for each year since 1877, the number accredited to tubercular disease, to influenza and grippe, and to diseases of the respiratory system, may be of interest:

[30] The statistics of deaths in Hamilton county are regularly omitted from the State reports because of their gross inaccuracy.

TABLE XVI.—DEATHS IN OHIO FROM TUBERCULOSIS, INFLUENZA AND DISEASES OF THE RESPIRATORY ORGANS.

Year ending March 31.	Total deaths from all causes.	Death from tuberculos disease.	Death from influenza and grippe.	Death from diseases of respiratory organs.	Percentage due to tuberculos disease.	Percentage due to tuberculosis and influenza.
1877	25,637	3,767	38	2,386	14.7	14.8
1878	22,662	3,156	27	2,005	13.6	13.7
1879	25,284	3,446	35	2,719	13.6	13.7
1880	24,477	3,366	17	2,210	13.7	13.8
1881	27,182	3,416	24	2,927	12.5	12.6
1882	27,944	4,111	48	2,046	14.7	14.9
1883	26,606	4,022	64	2,664	15.1	15.3
1884	24,364	3,929	84	2,162	16.1	16.5
1885	29,960	4,035	52	2,423	13.5	13.6
1886	28,133	4,140	59	2,090	14.7	14.9
1887	29,325	4,516	55	2,430	15.4	15.6
1888	31,630	4,522	71	2,917	14.3	14.5
1889	31,463	4,390	73	2,753	13.9	14.1
1890	32,440	4,240	1,046	3,183	14.	16.3
1891	34,333	4,177	1,367	4,165	12.2	16.1
1892	37,037	3,949	3,385	3,642	10.7	19.8
1893	32,983	3,672	767	3,092	11.2	13.5
1894	34,498	3,867	1,291	3,683	11.2	14.9
1895	36,225	3,918	987	3 901	10.8	13.5
1896	33,585	3,933	660	3,298	11.7	13.6

This table shows a close uniformity in the proportion of deaths from tubercular disease until the grippe appeared; since that date there has been a marked falling off in the percentage of deaths ascribed to tubercular disease, but when to these are added the deaths from influenza and grippe, the average percentage of deaths from the two classes of diseases combined has apparently undergone no change in the 20 years covered by these statistics; while if we add to these the deaths from other diseases of the respiratory organs (chiefly pneumonia) we find that there has been a marked increase in the total death rate from diseases affecting the lungs during the last seven years, the percentage of deaths ascribed to such diseases, in the deaths from all causes, being 23.4 for the thirteen years previous to the appearance of grippe, against 25.8 for the seven years following.

In the report of the New Jersey State Board of Health for 1898 is given a table (page 9) showing the deaths in New Jersey per 10,000 of population from classified diseases for the 20 years, 1879-98. From this table we find that the deaths in that state from consumption per 10,000 of population for the 11 years, 1879-89, averaged 25.85, while those from "acute lung diseases" averaged 19.88, those of the first class for every year exceeding those of the second. With 1890, however, the relative

proportion was suddenly reversed, and for the 9 years, 1890-98, the deaths averaged 21.37 for the first named class and 26.01 for the second, the number being invariably greater in the second class, while the total deaths from the two classes averaged 45.68 per 10,000 of population for the first 11 years and 47.38 for the last nine. These statistics, it will be seen, are in close harmony with those of Ohio.

Finally: The census reports of the United States show the following death rate per 100,000 of population in 1880 and 1890:

	Cause of death.	
	Consumption.	Respiratory diseases.
United States, 1880	182.3	215.1
United States, 1890	163.2	221.0
		Pneumonia.
England and Wales, 1880–'89	174.9	103.2
England and Wales, 1890	168.2	140.3
Ireland, 1880–'89	209.7	53.3
Ireland, 1890	215.7	70.3
Scotland, 1880–'89	201.7	104.0
Scotland, 1890	191.3	122.9

Except in Ireland, where both classes of diseases show an increase, these figures indicate a general falling off in consumption with a considerable increase in other forms of lung disease, this increase, on the whole, more than counterbalancing the apparent decrease of consumption. The statistics for Great Britain are quoted from the report of Dr. John S. Billings, special expert agent of the Eleventh Census of the United States.

The point suggested by all these statistics is that since the advent of the grippe many cases of incipient consumption have terminated in grippe or pneumonia and have been reported as such.

THE STATE CONTROL OF TUBERCULOSIS.

In several of the eastern states the attempt has been made to get control of this disease in cattle, but as yet these attempts have been only moderately successful. One of the most striking object lessons, showing how not to do it, has been furnished by the state of Massachusetts. In 1894 that state enacted a law providing for a general inspection of the cattle of the state, and for the testing with tuberculin of all cases in which tuberculosis was suspected and the destruction of all reacting animals. This law was afterwards so amended as to provide for full compensation to the owner for all animals killed as tuberculous, with certain reservations, and it seems to have been so loosely administered that compensation was allowed for animals killed as the result of private tests. A hint as to the actual outcome of such a law is given in the annual report for 1897, by the commission charged with its execution. They say:

"In many instances it is found that from some localities certain names appear upon our books more frequently than any other persons, seeming as though special individuals found it profitable to buy suspicious cows and sell to the state at an advance upon purchase price. Then, again, farmers last spring employed veterinarians to test cattle, with the idea, in many instances, of selling unprofitable cows to the state, and using the money to buy new ones that had not been over-grained and milked out.

"Further, local inspectors quarantine cows on suspicion that show no physical evidence of disease, which react to tuberculin, are killed and found to have slight lesion. The owner puts a new cow in place of the old one, that may not be free from tuberculosis, or, if she is, may in six months be diseased to the same extent (or more) as the old one, if he has neglected to disinfect the place where the old one stood, or has been careless about it."[31]

Under this system it seems that 24,685 cattle were tested in the 4 years, 1894-97, of which number 12,443, or 50 per cent, were condemned as tuberculous. For this work was paid, for the salaries and expenses of commissioners and agents, $123,061; for cattle killed, $494,543; and for other expenses, $107,342; a total of $714,966.[32]

Had the state been freed from bovine tuberculosis at this cost or at twice this cost the money would have been well spent; but the fact appears to be that, although there was a marked decrease in the number of cases of generalized tuberculosis, yet herds which were retested the last season, after having been cleaned out two years previously, and filled up since with tested cattle only, still showed a large percentage of tuberculous animals—in some cases a larger percentage than was found at the first test, the indications being that the disinfection of the barns had been neglected.

The laws of Ohio rightly forbid the offering for sale of unwholesome or adulterated food products; even so harmless an adulteration as the addition of pure water to milk is prohibited, while the exposure for sale of milk from diseased animals is forbidden under heavy penalties. The enforcement of these laws lies with municipalities, which have ample powers. These municipalities are vitally interested in securing a supply of pure food, and it is not only their right but their duty to see that the cows which furnish the milk sold on their streets shall show a clean bill of health, and that the meat exposed for sale within their limits shall have been taken from healthy animals.

It is probable that much more than half the cases of bovine tuberculosis in Ohio would be found in the large dairies supplying the cities and towns with milk. The rigid insistance by these municipalities that all cows furnishing milk to be sold on their streets should pass the tuberculin test; this test to be made only by duly authorized inspectors and to be repeated at least once each year, cows passing the test to be distinctly

[31] "Agriculture of Massachusetts," 1897. Report of Board of Cattle Commissioners, p. 492.

[32] Summary in American Agriculturist, 1898, p. 647.

tagged, those failing to pass to be immediately removed from the herd, would soon rid these dairies of the disease, and through them the cleaning out process would eventually reach practically the entire state. A herd once decimated by this test would only be filled up again with tested cows, and if the dairyman were his own insurer against loss from tuberculosis he would not permit his premises to remain infected with the germs of the disease.

This course would eventually clean out the disease from the state; for it would soon become impossible to sell cattle for either meat or dairy purposes which had not successfully passed the tuberculin test. In fact, this condition is already at hand with reference to pure bred cattle, as the breeders of such cattle are now subjecting their cattle to this test, because no well informed man will purchase an animal for breeding purposes which has not been thus tested.

The method of municipal control here suggested was adopted by Minneapolis in 1895, in a general law which does not order any cattle tested, but which merely says in substance—"If your cattle are not tested you cannot sell milk on our streets." No man can legally sell milk without a license, and a certificate of tuberculin test must be presented before a license may be granted. All cattle tested are tagged and numbered, and record is kept of all tests and of the disposition of the tested cattle.

The law has been confirmed by the supreme court of the state, the court holding that the city can require the inspection of a dairy herd from which milk is offered for sale within the city, although such herd may be kept outside the city limits, and also that the tuberculin test is not unreasonable.

The first enforcement of a regulation of this sort would involve hardship in the case of herds found infected with the disease, and the question of compensation might come in for consideration in such cases; but compensation should not be allowed the second time in the same herd.

THE LITERATURE OF BOVINE TUBERCULOSIS.

The literature of bovine tuberculosis is becoming quite voluminous. The Bureau of Animal Industry, U. S. Department of Agriculture, has published reports of original investigations on this subject, or items concerning it, in each of its annual reports since 1888; in its "Special Report on Diseases of Cattle" and in its Bulletins No. 3, 7 and 13. Similar investigations have been conducted by many of the Agricultural Experiment Stations of the United States and Canada, by state boards of health, and state live stock or tuberculosis commissions in America, and by similar commissions, or governmental agencies, in England and continental Europe. The publications of these commissions, as well as those of the experiment stations, are noted and frequently abstracted in the

Experiment Station Record, published by the Office of Experiment Stations, U. S. Department of Agriculture, and by the *Centralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten, Erste Abteilung,* published by Gustav Fischer, Jena, Germany.

IN CONCLUSION.

The present status of our knowledge concerning bovine tuberculosis may be summarized as follows:

1. The disease is caused by the growth within the animal tissues of a vegetble organism, *Bacillus tuberculosis.*

2. The bacterium of bovine tuberculosis has not been specifically differentiated from that producing tuberculosis in the human subject.

3. Tuberculosis is produced in the lower animals by inoculation with tuberculous material from human subjects.

4. Tuberculosis has been produced in man by inoculations with the tuberculous material from cattle.

5. The development of tuberculosis in human subjects has followed in so many cases upon the use of the meat or milk of tuberculous cattle that there is no room to doubt that the disease is transmitted from cattle to man in this manner.

6. That tuberculosis is a germ disease, caused as surely by contagion or infection as are smallpox and measles, is confirmed not only by the innumerable cases in which it has spread through herds from single infected animals, but also by the fact that many herds of cattle remain exempt from it, and this fact demonstrates the possibility of entire eradication of the disease.

7. In view of the experience of other states it would seem that the rational method of extirpating bovine tuberculosis lies not in the wholesale and immediate testing of all the cattle of the state and the slaughter of all reacting animals, but in such municipal action as will control the sale of both milk and meat within municipal limits.

PUBLICATIONS

OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

A complete list of previous publications of this Station may be found in Bulletin 95. Following are the titles of subsequent bulletins:

No. 96. The Army Worm and other insects; Wheat and Grass Sawflies; the Corn or Boll Worm; the Painted Hickory Borer; the Raspberry Cane Borer; the Peach Scale.
No. 97. Diseases of wheat and oats.
No. 98. Small fruits; cultural notes and comparison of varieties.
No. 99. Sugar beet investigations in 1898.
No. 100. A comparison of factory-mixed and home-mixed fertilizers.
No. 101. Experiments with oats.
No. 102. Soil and seed treatment and spray calendar for insect pests and plant diseases.
No. 103. The San José Scale in Ohio.
No. 104. Further studies upon spraying peach trees and upon diseases of the peach.
No. 105. Further studies of cucumber, melon and tomato diseases.
No. 106. I. The chinch bug. II. Experiments with insecticides.
No. 107. The Hessian Fly.
No. 108. Bovine Tuberculosis.

Ohio Agricultural Experiment Station.

BULLETIN 109

AND

EIGHTEENTH ANNUAL REPORT

FOR 1898-99.

WOOSTER, OHIO, JULY 1, 1899.

The Bulletins of this Station are sent free to all residents of the State who request them. Persons who wish their address changed should give both old and new address. All correspondence should be addressed to

EXPERIMENT STATION, WOOSTER, OHIO.

COLUMBUS, OHIO
FRED J. HEER, STATE PRINTER
1899

Eighteenth Annual Report

OF THE

Ohio Agricultural Experiment Station

For the Year Ending June 30, 1899.

Published by order of the State Legislature.

COLUMBUS, OHIO
FRED J. HEER STATE PRINTER

ANNOUNCEMENT.

The Ohio Agricultural Experiment Station is organized under an act of the General Assembly of Ohio, passed April 17, 1882, and supplemented by an act of Congress approved March 2, 1887.

The Station is prepared to test new varieties of grains, fruits and garden vegetables; to examine seeds that are suspected of being unsound or adulterated; to identify and name grasses, weeds and other plants; to identify insects and suggest measures for the control of such as are injurious, and to give advice concerning the prevention of the fungoid diseases which affect vegetation.

The Station is not prepared to furnish analyses of chemical or commercial fertilizers, as in Ohio that work is performed under direction of the Secretary of the State Board of Agriculture, at Columbus; but the Station will at all times respond to requests for advice concerning the use of such fertilizers.

The Station is not prepared to examine foods and dairy products suspected of adulteration, as that work is provided for in the Ohio Dairy and Food Commission, whose headquarters are at Columbus.

The Station is not at present prepared to offer advice or treatment for diseases of animals, but would refer all seeking such assistance to the Ohio Live Stock Commission, at Columbus.

Any citizen of Ohio has the right to apply to the Station for any information it can give, and all such applications will receive prompt attention.

Visitors to the Station are always welcome.

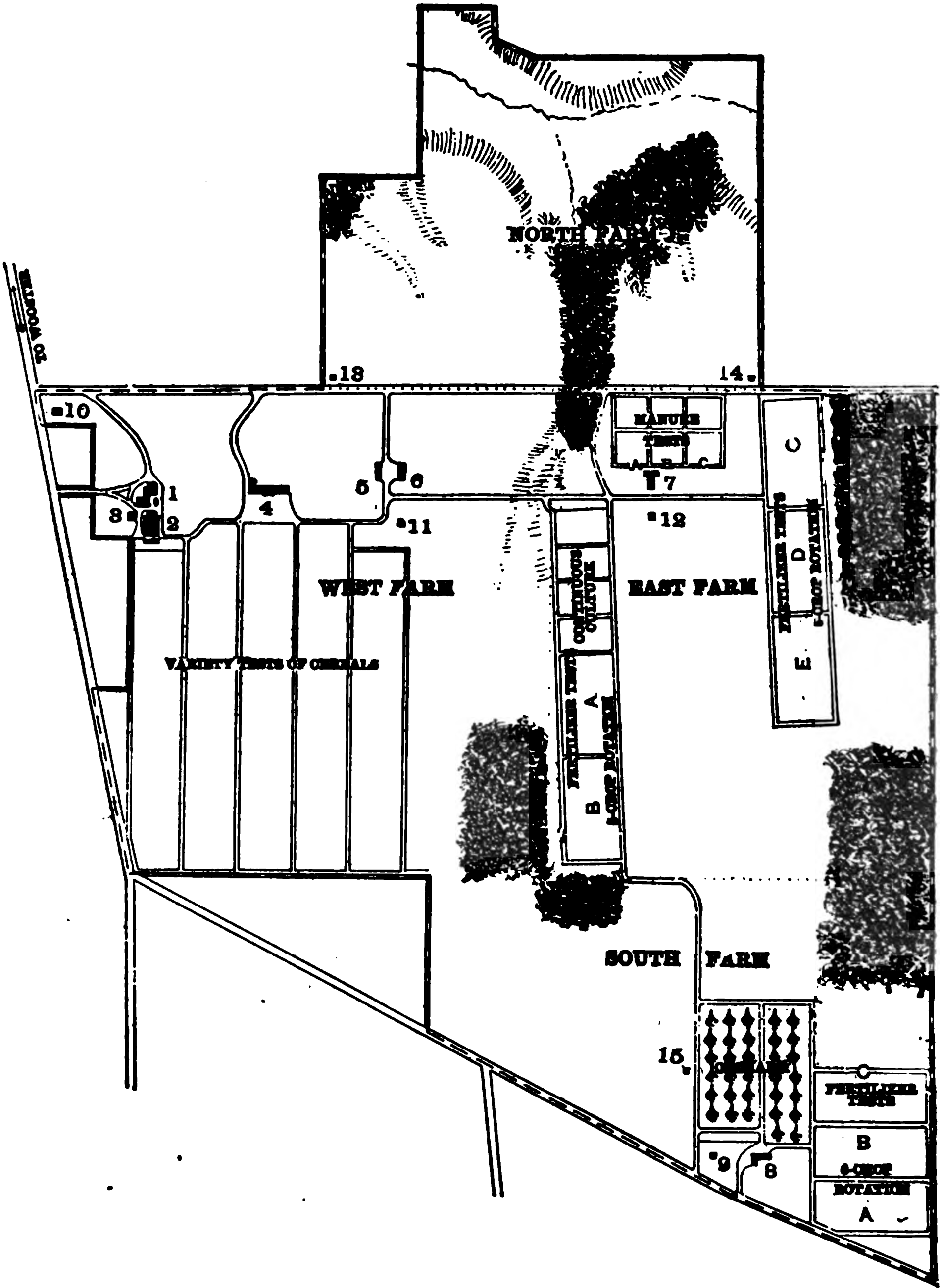
Address all communications to

EXPERIMENT STATION,
Wooster, Ohio.

ORGANIZATION OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.



FARM MAP—OHIO AGRICULTURAL EXPERIMENT STATION.

1, Main building.
2. Greenhouses.
8 Biological laboratory.
4. Dairy barn and creamery.
5. Tool house.
6. Horse barn.
7. East barn.
8. Horticultural barn and cold storage.
9. Residence of Horticulturist.
10. Residence of Director.
11. 12, 13, 14, 15. Dwellings occupied by foremen and laborers.

To His Excellency, ASA S. BUSHNELL, *Governor of Ohio.*

SIR: — I have the honor to transmit herewith the eighteenth annual report of the Ohio Agricultural Experiment Station, for the fiscal year ending June 30th, 1899.

R. H. WARDER, *Secretary.*

REPORT OF THE TREASURER.

To Hon. S. H. Ellis, *President of the Board of Control*:

Sir: — I respectfully submit herewith the financial report of this Station for the fiscal year ending June 30, 1899:

In Statements A, B, C and D, respectively, will be found a record of the receipts and expenditures from the various funds; Statement A being a statement of account with the annual appropriation received from the U. S. Treasury, and a copy of the report made to the Governor of the State, the Secretary of Agriculture and the Secretary of the U. S. Treasury; Statement B being a statement of account with the State Treasury; and Statement C showing the receipts and expenditures from farm produce and other sales.

The three statements, A, B and C, are combined in Statement D, which shows the total income and expenditures for the fiscal year.

STATEMENT A.

The Ohio Agricultural Experiment Station in Account with the United States Appropriation 1898-9.

Dr.

To receipts from the Treasurer of the United States, as per appropriation for the fiscal year ending June 30, 1898, as per act of Congress approved March 2, 1887		$15,000 00

Cr.

By expenditures for: —		
Salaries	$11,692 42	
Labor	1,867 87	
Postage and stationery	76 76	
Freight and express	83 46	
Heat, light and water	280 64	
Chemical supplies	58	
Seeds, plants and sundry supplies	242 31	
Fertilizers	13 95	
Feeding stuffs	210 19	
Library	107 55	
Tools, implements and machinery	156 23	
Furniture and fixtures	6 80	
Live stock	209 09	
Contingent expenses	10 00	
Building and repairs	42 15	
Total	$15,000 00	$15,000 00

I, the undersigned, duly appointed Auditor of the Corporation, do hereby certify that I have examined the books and accounts of the Ohio Agricultural Experiment Station for the fiscal year ending June 30, 1899, that I have found the same well kept and classified as above and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000.00, and the corresponding disbursements $15,000.00; for all of which proper vouchers are on file and have been by me examined and found correct.

And I further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

{ SEAL OF INSTITUTION }

Signed,
S. H. ELLIS,
Auditor of Board of Control.

Attest: CHAS. E. THORNE, *Custodian.*

I hereby certify that the foregoing statement of account to which this is attached, is a true copy from the books of account of the institution named.

P. A. HINMAN,
Treasurer of Board of Control.

STATEMENT B.

Ohio Agricultural Experiment Station in Account with the State Treasury.

Date of appropriation.	Appropriation for —	Total amount to the Station's credit.	Total amount expended.	Balance in treasury June 30, 1899.
1899..	Expenses of the Board of Control.....	$300 00	....	$300 00
	Sub-stations for field experiments.....	2,800 00	$501 65	2,298 35
	Bulletin illustration	400 00	....	400 00
	Special work in Entomology, Botany, Horticulture and Chemistry.........	3,000 00	....	3,000 00
	General repairs, labor and supplies....	3,500 00	2,646 84	853 16
	Totals for 1899..................	$10,000 00	$3,148 49	$6,851 51
	Balance of appropriations for 1897 and 1898, brought forward July 1, 1898—			
1898..	Expenses of the Board of Control.....	$500 00	$137 03	$362 97
	Sub-stations for field experiments.....	1,916 64	1,916 64	....
	Bulletin illustration	500 00	56 35	443 65
	Special work in Entomology, Botany, Horticulture and Chemistry........	3,662 44	3,516 03	146 41
	General repairs, labor and supplies....	107 83	107 83	....
	Investigation of tuberculosis..........	1,000 00	875 39	124 61
	Furniture and fixtures................	778 50	778 50	....
1897..	Bulletin illustration	83 90	83 90	....
	Totals	$18,549 31	$10,620 16	$7,929 15

STATEMENT C.

Ohio Agricultural Experiment Station in Account with the Produce Fund.

To Receipts:—

June 30, 1899.		
From sales of agricultural produce	$1,409 55	
" dairy produce	222 22	
" live stock	1,340 30	
" horticultural produce	1,427 59	
labor	93 77	
rents	927 00	
miscellaneous sales	445 01	
testing dairy cattle (milk test)	41 00	
inspection of nurseries	216 81	
chemical analysis	10 00	
Northeastern Sub-station	205 28	
Northwestern Sub-station	185 20	
O. S. U. Sub-station	27 44	
Total receipts for the year		$6,551 17
By total expenditures		5,719 11
Balance forward July 1, 1899		$832 06

By Expenditures:—

June 30, 1899.		
For salaries, special and temporary services	$21 25	
labor	2,510 14	
postage and stationery	55 13	
freight and express	169 71	
heat, light and water	63 24	
chemical supplies	12 27	
seeds, plants and sundry supplies	306 21	
fertilizers	1 20	
library	217 39	
tools, implements and machinery	141 65	
furniture and fixtures	44 12	
live stock	2 40	
traveling expenses	59 84	
contingent expenses	243 75	
building and repairs	515 98	
miscellaneous	369 71	
Total expenditures for the year		$4,733 99
By balance brought forward July 1, 1899		985 12
Total		$5,719 11

STATEMENT D.

TOTAL RECEIPTS AND EXPENDITURES OF THE OHIO AGRICULTURAL EXPERIMENT STATION FOR THE YEAR ENDING JUNE 30, 1899.

Total Receipts.

From U. S. Treasury		$15,000 00	
State appropriations		10,000 00	
miscellaneous receipts		6,551 17	
Total receipts for the year			$31,551 17
To balance brought forward			7,564 19
Total			$39,115 36

Total Expenditures.

For salaries of technical and office staff		$11,542 43	
salaries, special and temporary services		64 75	
salaries, foremen and skilled laborers	$3,470 76		
ordinary labor	5,934 05		
Total labor		9,404 81	
publications		276 20	
postage and stationery		380 28	
freight and express		446 69	
heat, light and water		414 31	
chemical supplies		153 68	
seeds, plants and sundry supplies		1,082 16	
fertilizers		89 57	
feeding stuffs		759 98	
library		476 06	
tools, implements and machinery		990 32	
furniture and fixtures		883 35	
scientific apparatus		138 73	
live stock		564 12	
traveling expenses		825 46	
contingent expenses		510 25	
building and repairs		981 29	
miscellaneous		369 71	
Total expenditures for the year			$30,354 15
By balance carried forward			8,761 21
Total			$39,115 36

Respectfully submitted,

P. A. HINMAN, *Treasurer.*

REPORT OF THE DIRECTOR.

HON. J. T. ROBINSON,

President of the Board of Control:

SIR: — During the period covered by the present report the Station's work has been actively pushed forward along all its various lines. Seasonal conditions have, in general, been favorable to the work, and the careful preparation of the land for field and orchard experiments is now bearing fruit in valuable results.

INSPECTION OF NURSERIES.

The reasons given in our last report for continuing this work still exist, as the action of other states and Canada has made such inspection essential to the commercial handling of nursery stock. So long as the policy of nursery inspection remains in the experimental stage, the present system of voluntary inspection by the Experiment Station is probably the best that can be devised; but if the present statutes of many of our states and of the Canadian provinces remain unchanged, it will be necessary for the General Assembly to make definite provision for this work in Ohio.

This Station has been especially fortunate in being relieved from the various lines of police work which have grown up around many similar institutions, and which necessarily interfere with the scientific research which is the legitimate work of an Experiment Station; but the fact that the Station has been able to step forward to the protection of our nursery interests at a most critical juncture is an apt illustration of its value to the varied industries of the State.

BOVINE TUBERCULOSIS.

The last General Assembly appropriated $1,000 to the Station for investigation of tuberculosis, with special reference to the disease in cattle. With this sum only a preliminary study of the problem could be made, as the amount was not sufficient to permit the employment of experts in the field of animal bacteriology. It was therefore decided to dispose immediately of the larger number of the tuberculous cattle which were on the Station farm at the time the appropriation was made, holding only a few for a few months longer for further study. These were publicly slaughtered on the eleventh of April, 1899. This slaughter was attended by several hundred veterinarians, health officers and others.

The outcome of this test, and of the investigations which preceded it, are given in Bulletin 108, which contains also the results of an inquiry respecting the prevalence of bovine tuberculosis throughout the state, and the possible connection between bovine and human tuberculosis. In the pursuit of this investigation the Station has been assisted by nearly four hundred and fifty physicians, veterinarians and health officers, located in all parts of the state, who have most kindly responded to circulars of inquiry. This investigation has demonstrated the prevalence of tuberculosis in many of the herds of cattle from which the milk supply of our cities is drawn, while indicating a comparative rarity of the disease among the small herds of the general farmers. It has not scientifically demonstrated the direct communication of tubercular disease from cattle to man, since to make such a demonstration it would be necessary to exclude all other sources of possible infection, but it has brought out the fact that many physicians have had reason to strongly suspect the origin of tubercular disease in some of their patients to be in the meat or milk supply.

The vital statistics of the National census show that more deaths from tubercular disease occur in Ohio during the first two years of life than during any ten years following; but the replies to our inquiry, coming from physicians and veterinarians in all parts of the state and practicing in the country, in the city, or in both, show that both bovine and infantile tuberculosis are extremely rare on the farms of the state, but that infantile tuberculosis is common in the cities and that bovine tuberculosis is common in the large dairy herds from which the milk supply of cities is drawn. Moreover, postmortem examinations are indicating that infantile tuberculosis is even more common than the census figures would indicate, and that in infants the disease is manifested in the digestive tract more frequently than in adults.

The logical inference to be drawn from these facts is that a tuberculous milk supply is responsible for many, if not most, of the infantile deaths from this disease. A more complete demonstration of this responsibility must be left for more thorough investigation than it has been possible to make with the resources thus far at command.

The slaughter test mentioned, in connection with the two years' study of this disease at the Station, in which there was opportunity to verify the tuberculin diagnosis by postmortem examination in 38 cases, has shown that, by means of the tuberculin test, it is possible to detect the presence of tuberculosis in cattle in the earliest stages of infection, and that there is sufficient time, after the first infection, to convert the animal into beef before the disease will have become so generalized as to render the meat unsafe for food, if properly cooked. This is a point of great practical importance, since it reduces to the minimum the necessary loss from attempts to eradicate the disease.

Since the slaughter in April the remaining cattle on the Station

farm, about 50 head, have been tested with tuberculin, with three cases of reaction. These were immediately isolated. It was fully expected that occasional cases would develop in the herd for some time to come, and we have therefore no reason to abandon the hope that perseverance in our present course will eventually rid the herd completely of this disease.

While this investigation has been very incomplete and unsatisfactory, from the scientific point of view, because of the impossibility of entering upon a thorough investigation with the funds at command, yet the publicity of the Station's work and the general distribution of the bulletin reporting it, which has been sent, not only to nearly 40,000 farmers, but also to more than 10,000 physicians in Ohio, has turned the attention of the people to this disease and its possible connection with human tuberculosis in such measure as to insure a more thorough study of the question in the future.

The Station would not pose as an alarmist in this matter. A disease which is responsible for one-seventh of all human deaths needs no exaggeration to depict its horrors. But the present trend of scientific investigation is to mitigate rather than intensify these horrors. We are beginning to see the way to the control of this disease, and that this way lies not through drastic legislation nor through the wholesale sacrifice of our herds. It would be difficult to imagine a work in which greater hope of beneficial results is held out than through the pursuit of the line of investigation which this preliminary survey has outlined, and this work is for the direct benefit of all classes, those who reside within the city as well as those whose living comes directly from the farm.

In this case as in that of nursery inspection, the attitude of surrounding states has made necessary some action by the General Assembly, looking toward the better protection of the live stock industry of Ohio, while a due regard for the health of our citizens must impel our municipalities to cause a more thorough inspection of their meat and milk supplies. These are lines of police work which may well be left to other agencies than the Experiment Station; but there is a vast field of scientific research which must be the guide to legislation in such lines, and for this work the State has no other organization than the Experiment Station.

THE STOMACH WORMS OF SHEEP.

The many reports concerning the ravages of these parasites, which find their way to the agricultural press, and the complaints frequently received at the Station, show that they are causing immense losses to the flock-masters of Ohio. A report of an investigation on this point, made by Prof. Ch. Julien, of the Experiment Station at Grignon, France, which has been translated and published as Press Bulletin No. 195 of this Station, has brought to the notice of our farmers a remedy which seems

to be of great assistance in controlling the parasites, judging by our own experience in its use and by the many favorable reports from flock-masters who have tried it.

VARIETY AND CULTURAL TESTS.

The variety and cultural tests of the Station have been brought up to date with respect to oats, by the publication of Bulletin 101, which includes a comparison of varieties, with experiments on methods of seeding, condition and quality of seed, preparation of seed bed, seeding on different soils to exterminate smut and quantity of seed per acre. Similar experiments with corn and wheat await publication.

THE MAINTENANCE OF FERTILITY.

The investigations in this great problem have been continued on the plans described in previous bulletins. Bulletin 100 contains a report of progress in the comparison of factory-mixed with home-mixed fertilizers, showing results still more favorable to home mixing than those previously published, and a more complete report of the results thus far attained in the general study of this question than has heretofore been published is being prepared, to be issued in Bulletin 110.

HORTICULTURAL DEPARTMENT.

In the spring of 1898 the Station apple orchard set about half a crop of fruit, but before picking time the apples were all on the ground — the work of the codlin moths, which finding no fruit in the neighboring orchards redoubled their attacks upon this one. We have been able, by spraying, to hold this pest in check until midsummer; but after this period the difficulty of getting poison into the down-turned calyx, and the danger of lodging an unsafe excess of it in the cavity around the stem, together with the great influx of moths bred in neighboring orchards, add factors to the problem which have prevented its satisfactory solution.

Bulletin 98 of this department is devoted to cultural and variety tests of small fruits, and Bulletin 102, the joint work of the Horticulturist, Entomologist and Botanist, is a new and enlarged edition of the Spray Calendar, which had previously been compiled at the request of the State Horticultural Society.

ENTOMOLOGICAL DEPARTMENT.

Four bulletins have been issued by this department during the year. Bulletin 96, on "The Army Worm and other insects", contains notes on the army worm, wheat and grass saw-flies, the Corn or Boll-worm, the Painted Hickory borer, the Raspberry Cane borer and the Peach scale. Bulletin 103 is a discussion of the San José scale problem in Ohio in 1898, and

contains the report of experiments in the use of whale oil soap and kerosene in the orchard, and of hydrocyanic acid gas in the nursery. The results following the use of kerosene have not been satisfactory, the trees too often being injured or killed by the treatment. The experiments with whale oil soap resulted not only in the destruction of the scale, but also in the prevention of leaf curl. Bulletin 106 includes a discussion of the possible migrations of the chinch bug, and a report of experiments with kainit, tobacco, whale oil soap and bisulphide of carbon as general insecticides. Bulletin 107 is a review of the history of the Hessian fly, with report of experiments in its control.

The work of nursery inspection has consumed much of the time both of the chief of this department and of his assistant.

DEPARTMENTS OF BOTANY AND CHEMISTRY.

Bulletin 97, entitled "Some diseases of wheat and oats", gives the details of successful experiments in the prevention of the smuts of wheat and oats, with description of the rust, scab and glume-spot of wheat. Bulletin 99 reports the progress of the investigation on the suitability of the soils and climate of Ohio to the production of the sugar beet, begun in 1897, in coöperation with the National Department of Agriculture on the one hand, and with many farmers, scattered throughout the state, on the other. These experiments are being continued during 1899 on the same general plan. Bulletin 104 reports the continuance in 1898, by Mr. William Miller, of Gypsum, Ottawa county, of experiments carried on by the Station in his orchards through the seasons of 1895, 1896 and 1897 in the spraying of peach trees, a series of experiments which have demonstrated the possibility of controlling the leaf curl by the use of dilute Bordeaux mixture. The bulletin also reports studies upon crown gall and peach yellows. Bulletin 105 is a report of further studies of cucumber, melon and tomato diseases.

The experiments of the Station in the control of injurious insects and fungous diseases are bearing fruit in a steadily increasing use, on the part of the farmers and of fruit growers, of the methods of prevention and control which these experiments demonstrate. Hitherto the investigations in these fields have been hampered by lack of suitable facilities for such research. The building erected by this Station in 1893 for biological research was, we believe, the fourth building erected exclusively for that purpose in America. It is a one story structure, containing two work rooms, each 12 x 15 feet in size, with two glass houses, each 14 x 28 feet. One side of this building is used by the Entomologist, the other by the Botanist. Its purpose is to afford opportunity for the study of the life history of insects and fungous parasites under conditions of absolute control, the clues furnished by such study often leading to practical results of the greatest value.

Experience has shown this building to be far too small for the work for which it was designed. Moreover, the Horticultural work of the Station has come to a point where larger facilities are urgently needed for the culture of plants under glass. The Station needs, in short, a conservatory, sufficiently large to permit accommodations for the lines of work indicated.

ACKNOWLEDGMENTS.

The following publications have been received during the year as donations to the Station's library, or in exchange for its bulletins:

BOOKS, PAMPHLETS AND SCIENTIFIC PERIODICALS.

Agricultural experiment Stations: The bulletins of all the experiment stations of the United States and Canada are regularly received. Cloth-bound reports have been received from the following stations:

Connecticut State Station, annual report for 1898. Connecticut Storrs Station. annual report for 1898. Cornell University Station, annual report for 1897. Georgia, biennial report for 1897–8. Maine. annual report for 1898. Michigan, annual report for 1897. Minnesota, annual report for 1898. New York State Station. annual report for 1897. North Carolina, annual report for 1898–9. Oklahoma, annual report for 1898–9. Pennsylvania, annual report for 1897. Texas, annual reports for 1897 and 1898. Vermont, annual report for 1897–8. Wisconsin, annual report for 1898.

Agenda Agricole et Viticole, 1900, V. Vermorel, Villefranche, Rhone, France.

Augustana Library, Rock Island, Ills.: Mechanical composition of wind deposits, by Johan August Uddin.

Arkansas Bureau of Mines, Manufactures and Agriculture, Frank Hill, Commissioner: annual report for 1897–8.

American Museum of Natural History, Central Park, New York City: Bulletins.

Axtell-Rush Publishing Co., Pittsburg, Pa.: Vol. XV of the National Stockman and Farmer, bound.

Baeszler, Dr. P.: Bericht über die Thätigkeit der Agriculturchemischen Versuchs- und Samencontrolstation in Koslin für das Jahr 1897.

Barbados Botanical Station, J. R. Bovell, Supt.: Observations of the agricultural chemistry of the sugar cane.

Baron de Hirsch Agricultural and Industrial School: catalogue, 1898.

Berattelse ofver Skadeinsekters upptradande I Finland. Afgiven af Enzio Reuter.

Boletin de Agricultura, Mineria é Industrias, and Boletin Mensual del observatorio Meteorologica Central de Mexico: Publicado por la Secretaria de Fomento, Colonizacion é Industria de la Republica Mexicana.

Boletin do Instituto Agronomico do Estado de Sao Paulo em Campinas, Brazil.

Boletin de Agricultura Tropical, San José de Costa Rica, A. C.

Boletin de la Sociedad Nacional de Agricultura, Monjitas, Chili.

Boston Public Library, Herbert Putnam, Librarian: Annual report, 1897–8.

Botanisches Museum und Laboratorium für Waarenkunde zu Hamburg: Bericht über die Thätigkeit der Abteilung für Samencontrole, 1895, 1896, 1897 und 1898, erstattet von A. Voigt.

Bureau of Animal Industry, U. S. Department of Agriculture, Dr. D. E. Salmon, Chief: Fourteenth and Fifteenth annual reports.

Bureau of Statistics, U. S. Treasury, O. P. Austin, Chief: Foreign Commerce and Navigation of the United States. Statistical Abstract of the United States. Monthly Summary of Finance and Commerce.

Canada: Report of Dominion Commissioner of Agriculture and Dairying, for 1897; Hon. James W. Robertson. Commissioner, Ottawa.

Commercial relations of the United States, 1898, 2 vols.: U. S. Department of State.

Colorado College Studies: Papers read before the Colorado College Scientific Society.

Connecticut Board of Agriculture, T. S. Gold, Secretary: Reports for 1895 and 1896.

Cornwall County Council: Report of committee on agricultural experiments, W. Hawk, Chairman, Kernock, St. Mellion, England.

Distribution of grants for agricultural education and research in the year 1898–99. Annual report to the Board of Agriculture, P. G. Craigie, Sec. 4, Whitehall Place, London, S. W., England.

Emmerling, Prof. Dr. A.: Jahres-Bericht der Agriculturchemischen Versuchstation in Kiel für 1898.

Entomological papers, from Chas. P. Lounsbury, Colonial Entomologist, Cape Colony, South Africa.

Entomological reports and bulletins from Dr. E. P. Felt, State Entomologist, Albany, N. Y.

Explorations in the far North, by Frank Russell: Published by the State University of Iowa.

Forestry, a Primer of: Bulletin 24 of the Division of Forestry, U. S. Department of Agriculture, by Gifford Pinchot, Forester.

German Kali Works, New York City: Reports of European experiments with fertilizers.

Hawaiian Experiment Station, Walter Maxwell, Director: Work of the year 1899.

Future of our Wine Industry and the Results of Manuring Vineyards in Europe and Australia: By F. E. H. Krichauff, Chairman of Agricultural Bureau of South Australia.

Hollrung, Dr. M.: Neunter Jahresbericht der Versuchstation für Pflanzenschutz zu Halle, a. S. 1897. Jahresbericht über die Neurungen und Leistungen auf dem Gebiete des Pflanzenschutzes, 1898. Untersuchungen über die zweckmässigste Form der Kombination von Kupferkaltigen Fungiciden mit Seiflangen.

Illinois Live Stock Commission, C. P. Johnson, Sec.: Reports for 1897 and 1898.

Illinois State Horticultural Society, L. R. Bryant, Sec.: Transactions, 1897 and 1898.

Imperial University, College of Agriculture, Komaba, Tokyo, Japan: Bulletins.

Indiana Geological Survey, W. S. Blatchley, State Geologist: Annual reports for 1897 and 1898.

Indiana Horticultural Society, Prof. James Troop, Sec.: Transactions, 1896 and 1897.

Iowa State University: Bulletins from the Laboratories of Natural History, Vol. V. No. 1.

Jamaica Botanical Department, William Fawcett. Director: Bulletin, Vol. V, App. II.

Kansas Academy of Science. Bernard B. Smyth, Librarian: Transactions, 1897–8.

Kansas State Board of Agriculture, F. D. Coburn, Sec.: Eleventh biennial and quarterly reports for 1897–8.

Klein, Dr. J.: Bericht über die Thätigkeit des Milchwirthschaftlichen Instituts zu Proskau, für das Jahr 1896–7.

Lawes, Sir. J. B.: Rothamsted Memoirs on Agricultural Chemistry and Physiology, by Sir John Bennet Lawes and Sir J. Henry Gilbert, Vol. VII (Supplement).

Lindeman, K.: The most injurious insects of tobacco in Bessarabia.

Maine Registration Report, A. B. Young, M. D., Registrar: Vital Statistics for 1897.

Maine State Board of Agriculture, B. Walker McKeen, Sec.: Bulletins for 1898–9.

Maine State Board of Health, A. B. Young, M. D., Sec.: Annual report for 1897.

Mallophaga, New, Parts I, II and III, by Vernon L. Kellogg, Professor of Entomology, Leland Stanford, Jr. University, California.

Massachusetts State Board of Agriculture, James W. Stockwell, Sec.: Annual reports for 1892 and 1898.

Michigan Horticultural Society, Edwy. C. Reid, Sec.: Proceedings, 1896 and 1897.

Michigan State Board of Agriculture, J. H. Butterfield, Sec.: Annual report of State Weather Service for 1896.

Milk Inspector of St. Louis: Annual report for 1898–99, by Howard Carter, M. D.

Minneapolis Public Library, James Kendall Hosmer, Librarian: Annual report and quarterly bulletin, 1898–99.

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National Farmer and Stock Grower, National Stock Yards, Chicago, Ill.
National Fruit Grower, St. Joseph, Mich.
National Provisioner, New York, N. Y.
National Stockman and Farmer, Pittsburg, Pa.
North American Horticulturist, Monroe, Mich.
Ohio Farmer, Cleveland, Ohio.
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Pacific Bee, Sacramento, Cal.
Pacific Coast Dairyman, Tacoma, Wash.
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Crawford County News, Bucyrus.
Cumberland Echo, Cumberland.
De Graff Journal, De Graff.
Democrat, Pomeroy.
Democratic Herald, Delaware.
Fremont Journal, Fremont.
Greenville Democrat, Greenville.
Hardin County Republican, Kenton.
Jacksonian, Wooster.
Medina County Gazette, Medina.
Monroe Journal, (German), Woodsfield.
News Democrat, Georgetown.
Ohio State Journal, Columbus.
Press-Review, Payne.
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Kansas Semi-Weekly Capital, Topeka, Kan.
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Rural Topics, Morgan City, La.
Salt Lake Herald, (Semi-Weekly), Salt Lake City, Utah.
Weekly Union, Manchester, N. H.
Weekly World-Herald, Omaha, Neb.

The Station is also under obligations for the following favors:

SEEDS, PLANTS AND MISCELLANEOUS DONATIONS.

Albaugh Nursery Co., Phoneton, O.: Several varieties of peach trees.
Allen Color and Chemical Co., New York City: Packages of colored arsenoids.
Botanic Garden at Sibpeer, near Calcutta, India: Seeds of cucurbitaceæ.
Burpee, W. A. & Co., Philadelphia, Pa.: 45 varieties of seeds.
Davis, James, Brandt, O.: 1 variety of strawberry plants.
Deming Co., The, Salem, O.: 1 Knapsack sprayer.
Dorner, Fred & Son, Lafayette, Ind.: Several varieties of carnation plants.
Eisele, C., Philadelphia, Pa.: 1 variety of carnation plants.
Fisher, John W., Wigginsville, O.: 1 variety of grape.
Ford Seed Co., Ravenna, O.: 1 variety of potatoes.
Garretson, Amos, Pendleton, Ind.: 1 variety of raspberry plants.
Goulds Manufacturing Co., Seneca Falls, N. Y.: 1 spray pump.

Hancock, Geo. & Son, Grand Haven, Mich.: Several varieties of carnation plants.

Herr, Albert, Lancaster, Pa.: 8 varieties of carnations.

Hill, E. G. & Co., Richmond, Ind.: Several varieties of carnations.

Hine, J. P., Shinrock, O.: Horn-fly trap.

Huntley, H. D., Chestnut Grove, O.: 1 variety of strawberry plants.

Kirtland, Dr. W. H., Massillon, O.: 1 variety grape cuttings.

Knapp, L. M., Florence, O.: 1 variety of potatoes.

Leffel, A. D., Springfield, O.: 1 variety of raspberry plants.

Lehman, S. J. & Co., Enon, O.: 1 variety of strawberry plants.

Maiden, J. H., Director Botanic Gardens, Sidney, New South Wales: Seeds of cucurbitaceæ.

May, John M., Summit, N. J.: Several varieties of carnations.

Miller, D. J., Saltillo, O.: 2 varieties of strawberry plants.

Moore, S. K., Zanesville, O.: 3 varieties of apple scions.

Myers & Son, Bridgeville, Del.: 1 variety of strawberry plants.

Nichols Chemical Co., Laurel Hill, N. Y.: Package of Laurel Green.

Overholser, Daniel: 1 variety of strawberry plants.

Owen, W. H., Catawba Island, O.: 50 pounds whale oil soap.

Persing, H. L., Clyde, O.: 1 variety each of plum and peach trees.

Pratt, Geo. L., Ridgeway, N. Y.: Canker-worm moth trap.

Riehl, A. E., Alton, Ill.: 1 variety of strawberry plants.

Scab-cure Dip Co., Chicago, Ill.: Package of "Nikoteen".

Sheller, J. H., Bryan, O.: 1 variety of strawberry plants.

Shelmire, W. K., Avondale, O.: Several varieties of carnation plants.

Streator, Geo., Garrettsville, O.: Several varieties of seeds and plants.

Superior Drill Co., Springfield, O.: Use of beet drill.

Swift & Co., Boston, Mass.: 5 pounds arsenate of lead.

Swift & Co., Union Stock Yards, Chicago.: 400 pounds ground tankage.

United States Department of Agriculture, Washington, D. C.: 13 varieties of foreign strawberry plants and many varieties of seeds.

Van Orman, F. B., Lewis, Iowa.: 1 variety of potatoes.

Whinton, W. W., Wakeman, O.: 1 variety of potatoes.

Wiley & Co., Cayuga, N. Y.: 1 variety of potatoes.

In conclusion it is my very pleasant privilege to be able to report another year of united effort on the part of the Board of Control and members of the Station staff.

Respectfully submitted,

CHAS. E. THORNE,

Director.

APPENDIX.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

1897-98.

CONTENTS.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 109. JULY 1, 1899.

METEOROLOGICAL SUMMARY FOR 1898.

BY C. A. PATTON.

EXPLANATION OF TABLES.

The following tables contain statistics of temperature, rainfall, etc., for the year, and are compiled from data obtained by daily observations. T stands for "trace" — less than .01 inch of rainfall. Temperature is given in degrees Fahrenheit.

Table I shows the daily rainfall at the Station during the year in inches and hundredths.

Table II shows the daily mean temperature for each day of 1898, with the monthly mean and eleven years' average.

Table III gives a comparison of the monthly mean temperature and rainfall for the Station, with the eleven years' average for the same.

Table IV gives a comparison of the monthly mean temperature and rainfall for the State, with the eleven years' average for the same.

Table V gives the monthly mean temperature and rainfall for the Station and State for 1898, with the eleven years' average for the same.

Table VI contains the mean temperature, the highest and lowest temperatures, with the range of temperatures for each month; the number of clear, fair, and cloudy days; the rainfall and prevailing direction of wind, for both the Experiment Station and State for 1898.

Table VII contains the principal points of interest on temperature, state of weather and rainfall for the Station during the year, and a grand summary for eleven years.

Table VIII contains the principal points of interest on temperature, state of weather and rainfall for the State during the year and a grand summary for sixteen years.

The statistics for the State and for this Station previous to 1893 are compiled from the publications of the Ohio Meteorological Bureau and State Weather Service, the ten-year average being computed from the observations of the Wooster Station of the Ohio Meteorological bureau, now located on the grounds of the Experiment Station one mile south of Wooster.

NOTES ON THE WEATHER AT THE STATION — SUMMARY BY MONTHS.

JANUARY.

The mean temperature was 31.6°, which is 4.5° above the Station average for January. The highest temperature, 64°, occurred on the 13th; the lowest, —1°, on the 2nd.

Cloudy weather prevailed; rain or snow fell on twelve days; the total precipiation was 4.10 inches, .7 inch above the Station average for January. The prevailing wind was West.

FEBRUARY.

The mean temperature was 27.4°, which is 1.7° below the Station average for February. The highest temperature, 64°, occurred on the 11th; the lowest, —9°, on the 2nd and 3rd.

Cloudy weather prevailed; rain or snow fell on thirteen days; the total precipitation was 2.27 inches, which is 1.06 inches below the Station average for February. The prevailing wind was Southwest.

MARCH.

The mean temperature was 43.3°, which is 7.6° above the Station average for March. The highest temperature, 71°, occurred on the 19th; the lowest, 12°, on the 1st.

Rainy weather prevailed: rain or snow fell on fifteen days; the total precipitation was 6.44 inches, which is 3.16 inches above the Station's average for March. The prevailing wind was Southeast.

APRIL.

The mean temperature was 45.3°, which is 3.3° below the Station average for April. The highest temperature, 77°, occurred on the 17th; the lowest, 16°, on the 3rd.

Cloudy weather prevailed; rain or snow fell on ten days; the total precipitation was 2.56 inches, which is .08 inch below the Station average for April. The prevailing wind was North.

MAY.

The mean temperature was 58.2°, which is .8° above the Station average for May. The highest temperature, 81°, occurred on the 21st; the lowest, 32°, on the 9th.

Rainy weather prevailed; rain fell on thirteen days; the total precipitation was 4.60 inches, which is .25 inch above the Station average for May. The prevailing wind was North.

JUNE.

The mean temperature was 68.7°, which is .8° above the Station average for June. The highest temperature, 90°, occurred on the 30th; the lowest, 40°, on the 22nd.

Clear weather prevailed; rain fell on eight days; the total precipitation was 2.70 inches, which is 1.51 inches below the Station average for June. Prevailing wind was North.

JULY.

The mean temperature was 74.5°, which is 3.7° above the Station average for July. The highest temperature, 96°, occurred on the 3rd; the lowest, 45°, on the 10th.

Clear weather prevailed; rain fell on nine days; the total precipitation was 6.79 inches, which is 2.64 inches above the Station average for July. The prevailing wind was South.

AUGUST.

The mean temperature was 71.1°, which is 2.5° above the Station average for August. The highest temperature, 90°, occurred on the 21st and 23rd; the lowest, 46°, on the 28th.

Clear weather prevailed; rain fell on twelve days; the total pretation was 6.79 inches, which is 2.64 inches above the Station average for August. The prevailing wind was South.

SEPTEMBER.

The mean temperature was 66.2°, which is 2.9° above the Station average for September. The highest temperature, 90°, occurred on the 1st, 2nd and 3rd; the lowest, 38°, on the 12th.

Clear weather prevailed; rain fell on seven days; the total precipitation was 2.15 inches, which is .8 inch below the Station average for September. The prevailing wind was South.

OCTOBER.

The mean temperature was 52.6°, which is 3.1° above the Station average for October. The highest temperature, 86°, occurred on the 3rd; the lowest, 24°, on the 29th.

Cloudy weather prevailed; rain fell on twelve days; the total precipitation was 4.28 inches, which is 1.70 inches above the Station average for October. The prevailing wind was Southeast.

NOVEMBER.

The mean temperature was 38.4°, which is 1.2° below the Station average for November. The highest temperature, 66°, occurred on the 4th; the lowest, 13°, on the 27th.

Cloudy weather prevailed; rain or snow fell on ten days; the total rainfall was 4.14 inches, which is .53 inch above the Station average for November. The prevailing wind was Southwest.

DECEMBER.

The mean temperature was 27.9°, which is 4.2° below the Station average for December. The highest temperature, 56°, occurred on the 22nd and 29th; the lowest, 1°, on the 14th.

Cloudy weather prevailed; rain or snow fell on thirteen days; the total precipitation was 2.29 inches, which is .17 inch below the Station average for December. The prevailing wind was Southwest.

METEOROLOGY — TABLE I.— RAINFALL.

DAILY RAINFALL AND MELTED SNOW FOR 1898 AT EXPERIMENT STATION.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	T	.05						1.30				
2		.05	.20	T	T	T						
3				.25	T			.57	T			
4							T	.48	.42	.15		.60
5		.10		T	.40					.40	1.80	
6	.33			T	.40				T	T	T	.10
7					.35				.12	.02		.05
8						.32		.59		T		.05
9	T	T		.18			.10				.90	T
10		T			.02	T					.52	
11	.10	.25	.17		.06	.33				.48	.05	
12	.38	.27	.40		.90	T		.21				.05
13	.13		.28			.33					.12	
14	T	.10		.42		.47	T	T		.06	.10	
15	.35	.20	.28		.36		1.48					
16	T			T	.78			.12	.05			
17	.05		.25				1.72	.10				.05
18		.15	.93	.02			.50	.04	.40	.96		
19	T	T	.41	.55	.82	.09		1.51			.10	.57
20	1.10	.72	.55	.03	.22		.58					.15
21		.17	.42		.10	T				1.10		.10
22	.50	.10	1.00		T				.76	.60	.10	.05
23	.38	.10	1.50	.72	.02				.30	.07		
24		T		.20				.50	.10			
25	.65	T		.09	T	.53	.13	.10				
26	.03	T				.23	T	.01		.10	.25	.02
27	T	T	.47			.40	T					T
28			.33		.17		1.26					
29	T										.20	
30			.15		T		.78			.10		.30
31	.10						.24			.24		.20
Totals	4.10	2.26	6.44	2.55	4.60	2.70	6.79	5.53	2.15	4.28	4.14	2.29
Average	.13	.08	.21	.08	.15	.09	.22	.18	.07	.14	.14	.07

METEOROLOGY—TABLE II.—TEMPERATURE.

MEAN TEMPERATURE FOR EACH DAY OF 1898 AT THE STATION.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	15.	10.	23.	35.	67.	62.	78.	73.	77.	69.	41.	25.
2	7.	5.	29.	37.	68.	67.	80.	73.	80.	73.	48.	33.
3	23.	1.	29.	28.	58.	63.	84.	76.	79.	76.	41.	33.
4	27.	18.	27.	35.	53.	65.	75.	70.	75.	74.	49.	32.
5	29.	32.	28.	27.	48.	69.	62.	66.	77.	69.	57.	26.
6	30.	18.	34.	30.	42.	70.	74.	70.	77.	59.	45.	24.
7	32.	31.	42.	39.	49.	72	74.	72.	68.	55.	45.	22.
8	37.	39.	46.	40.	52.	71.	78.	72.	58.	56.	44.	13.
9	29.	42.	49.	31.	51.	75.	73.	69.	60.	56.	45.	17.
10	32.	49.	52.	47.	54.	75.	58.	70.	5).	57.	48.	13.
11	37.	50.	53.	48.	58.	74.	69.	69.	54.	62.	38.	20.
12	51.	46.	55.	48.	57.	75.	63.	72.	55.	53.	31.	25.
13	48.	35.	50.	50.	52.	71.	73.	67.	63.	50.	33.	15.
14	40.	34.	40.	51.	59.	74.	76.	71.	67.	46.	60.	10.
15	38.	25.	42.	52.	60.	63.	79.	69.	69.	45.	40.	18.
16	29.	15.	56.	50.	60.	63.	76.	77.	68.	45.	35.	29.
17	23.	21.	53.	61.	50.	70.	78.	74.	68.	55.	41.	29.
18	30.	31.	45.	53.	56.	71.	79.	73.	74.	51.	46.	33.
19	34.	34.	56.	55.	63.	69.	80.	72.	65.	46.	44.	35.
20	42.	38.	49.	45.	64.	61.	80.	65.	61.	50.	44.	43.
21	36.	31.	49.	47.	69.	63.	76.	70.	61.	55.	52.	41.
22	36.	22.	63.	52.	70.	57.	71.	75.	69.	48.	40.	45.
23	38.	25.	46.	55.	68.	63.	79.	80.	66.	42.	28.	42.
24	31.	30.	34.	49.	66.	70.	79.	77.	65.	51.	26.	31.
25	35.	20.	38.	49.	62.	75.	78.	74.	65.	52.	30.	29.
26	36.	20.	49.	48.	60.	74.	78.	67.	64.	43.	22.	24.
27	27.	26.	58.	47.	59.	73.	76.	63.	58.	40.	22.	25.
28	28.	26.	54.	47.	61.	69.	77.	63.	58.	38.	22.	18.
29	27.	......	40.	52.	63.	66.	77.	69.	64.	41.	30.	40.
30	21.	......	35.	50.	57.	77.	72.	77.	71.	42.	32.	40.
31	23.	......	30.	......	55.	......	71.	78.	......	40.	......	21.
Monthly mean	31.6	27.4	43.3	45.3	58.2	68.7	74.5	71.1	66.2	52.6	38.4	27.9
Eleven-year average	27.1	29.1	35.7	48.6	57.4	67.9	70.8	68.6	63.3	49.5	39.6	32.1

METEOROLOGY—TABLE III.

MONTHLY MEAN TEMPERATURE AND RAINFALL FOR ELEVEN YEARS AT WOOSTER.

Temperature in degrees Fahrenheit.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1888	22.5	28.4	31.7	46.3	57.7	68.4	70.1	67.8	57.1	44.9	40.7	31.4	47.2
1889	31.1	29.9	38.7	47.1	57.8	64.5	70.0	66.0	60.8	45.3	39.3	40.7	48.6
1890	36.0	36.6	30.9	48.4	56.0	69.8	70.5	65.8	59.6	50.0	41.3	28.8	49.5
1891	30.0	34.0	32.0	49.0	52.0	68.0	68.0	71.0	68.0	49.0	38.0	37.0	49.6
1892	22.0	32.5	32.0	47.0	57.0	70.0	70.0	69.0	61.0	49.0	38.0	28.0	48.0
1893	18.0	28.0	38.0	50.1	57.6	69.8	72.0	67.9	63.2	52.3	37.7	30.9	48.7
1894	32.8	26.7	43.5	50.5	57.5	67.9	71.4	69.2	66.1	52.1	36.5	32.9	50.6
1895	21.9	17.9	32.4	49.5	59.4	69.9	68.6	70.9	66.5	44.2	40.4	32.8	47.8
1896	27.9	29.2	29.8	54.7	64.5	65.6	70.2	68.5	60.6	48.8	44.4	30.6	49.6
1897	24.0	30.0	39.3	47.2	53.4	64.3	73.2	67.0	66.7	55.9	40.7	31.8	49.4
1898	31.6	27.4	43.8	45.3	58.2	68.7	74.5	71.1	66.2	52.6	38.4	27.9	50.4
Averages	27.1	29.1	35.7	48.6	57.4	67.9	70.8	68.6	63.3	49.5	39.6	32.1	49.0

Rainfall in inches.

1888	3.52	2.43	3.34	2.48	3.82	2.31	4.54	4.35	1.92	3.18	4.95	1.39	3.18
1889	4.33	2.42	2.13	1.58	2.37	4.86	6.73	1.98	4.05	1.36	3.53	3.93	3.32
1890	4.71	6.20	4.37	3.10	6.01	5.57	2.67	4.66	5.12	7.45	2.61	1.74	4.51
1891	2.74	4.83	3.71	1.66	2.24	7.13	3.28	1.85	0.94	1.33	5.73	2.92	3.20
1892	2.67	2.67	3.38	2.44	7.69	7.89	4.73	2.69	3.20	0.37	2.06	1.74	3.46
1893	4.01	6.33	1.89	5.66	6.28	2.51	1.38	1.53	1.85	5.18	2.49	1.50	3.38
1894	2.19	3.37	2.36	1.74	4.41	2.23	1.38	0.76	4.07	2.53	2.41	3.15	2.55
1895	3.92	1.00	1.98	1.69	1.38	4.20	2.19	2.30	3.92	1.15	4.21	3.51	2.62
1896	1.73	2.27	3.67	3.34	3.41	3.98	8.05	1.96	5.16	0.71	1.78	2.41	3.21
1897	2.82	2.64	2.81	2.75	4.97	2.98	3.89	3.86	0.29	0.89	5.76	2.50	3.01
1898	4.10	2.27	6.44	2.56	4.60	2.70	6.79	5.53	2.15	4.28	4.14	2.29	3.99
Averages	3.34	3.33	3.28	2.64	4.35	4.21	4.15	2.86	2.97	2.58	3.61	2.46	3.31

METEOROLOGY—TABLE IV.

MONTHLY MEAN TEMPERATURE AND RAINFALL FOR ELEVEN YEARS FOR THE STATE.

Temperature in degrees Fahrenheit.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1888	24.3	30.5	34.2	49.2	59.1	70.4	72.1	70.4	60.3	47.9	42.9	33.3	49.2
1889	33.3	25.8	40.2	49.9	60.2	66.7	72.5	69.1	62.9	47.9	41.0	43.8	51.1
1890	38.8	39.4	34.5	51.3	59.2	73.3	73.1	68.8	62.1	52.7	43.9	31.2	52.3
1891	33.0	36.0	35.0	52.0	58.0	71.0	69.0	70.0	67.0	51.0	40.0	39.0	51.7
1892	24.0	35.0	35.0	49.0	59.0	73.0	73.0	71.0	64.0	52.0	38.0	29.0	50.1
1893	18.0	29.0	38.0	50.2	58.3	70.6	74.5	70.7	65.2	53.7	39.3	32.7	51.6
1894	37.7	28.9	45.1	50.6	60.0	71.3	74.3	71.2	67.8	53.9	37.5	33.9	52.3
1895	23.4	19.6	35.5	51.7	61.1	72.0	71.6	73.5	69.0	46.9	41.3	33.9	49.9
1896	29.4	30.5	32.4	56.7	67.9	69.5	73.2	71.8	62.7	49.0	45.1	32.9	51.7
1897	25.5	32.4	41.5	49.3	46.3	68.1	75.5	69.4	66.9	58.1	42.2	32.8	50.6
1898	32.4	30.0	45.0	47.2	61.0	71.9	76.0	73.5	67.8	53.1	38.8	28.8	52.1
Averages	29.1	30.6	37.9	50.6	59.1	70.7	73.2	70.9	65.1	51.5	40.9	33.7	51.1

Rainfall in inches.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1888	3.65	1.74	3.55	1.99	3.77	3.41	4.40	5.16	2.27	3.98	4.25	1.47	3.30
1889	3.13	1.35	1.50	1.79	3.71	4.13	4.25	1.50	3.62	1.78	4.02	2.81	2.79
1890	4.94	5.25	5.29	3.15	5.52	4.50	1.99	4.70	5.56	4.27	2.53	2.37	4.17
1891	2.82	4.91	4.19	2.13	2.20	4.82	3.82	3.07	1.50	1.76	5.00	2.39	3.21
1892	2.05	3.27	2.16	2.63	4.63	6.73	3.13	6.15	1.27	0.67	2.62	1.85	3.09
1893	2.56	5.13	2.09	6.37	4.97	3.34	2.49	2.17	1.57	4.24	2.09	2.61	3.30
1894	2.14	2.79	2.16	2.31	4.00	2.65	1.56	1.67	3.31	2.01	2.17	2.98	2.47
1895	4.00	0.69	1.59	2.11	1.80	2.44	2.00	2.96	1.66	1.22	4.11	3.85	2.37
1896	1.67	2.21	3.34	2.78	2.67	4.81	8.11	3.38	5.13	1.20	2.63	1.65	3.29
1897	1.93	3.64	5.17	3.27	3.93	2.85	4.65	2.72	0.78	0.64	6.62	2.39	3.21
1898	5.25	2.32	6.23	2.38	4.10	2.86	3.98	4.50	2.56	3.72	3.17	2.71	3.65
Averages	3.10	3.03	3.39	2.81	3.75	3.87	3.67	3.45	2.66	2.32	3.56	2.46	3.17

METEOROLOGY — TABLE V.

MEAN TEMPERATURE AND RAINFALL FOR THE STATION AND STATE, 1898 AND FOR ELEVEN YEARS.

Temperature in degrees Fahrenheit, rainfall in inches.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Mean temperature at the Station, 1898	31.6	27.4	43.3	45.3	58.2	68.7	74.5	71.1	66.2	52.6	38.4	27.9	50.4
Eleven years' average temperature at the Station	27.1	29.1	35.7	48.6	57.4	67.9	70.8	68.6	63.3	49.5	39.6	32.1	49.
Mean temperature for the State, 1898	32.4	30.0	45.0	47.2	61.0	71.9	76.0	73.5	67.8	53.1	38.8	28.8	52.1
Eleven years' average temperature for the State	29.1	30.6	37.9	50.6	59.1	70.7	73.2	70.9	65.1	51.5	40.9	33.7	51.1
Rainfall at the Station, 1898	4.10	2.27	6.44	2.56	4.60	2.70	6.79	5.53	2.15	4.28	4.14	2.29	47.85
Eleven years' average rainfall at the Station	3.34	3.33	3.28	2.64	4.35	4.21	4.15	2.86	2.97	2.58	3.61	2.46	39.75
Rainfall for the State, 1898	5.25	2.32	6.23	2.38	4.10	2.86	3.98	4.50	2.56	3.72	3.17	2.71	43.78
Eleven years' average rainfall for the State	3.10	3.03	3.39	2.81	3.75	3.87	3.67	3.45	2.66	2.32	3.56	2.46	38.09

METEOROLOGY—TABLE VI.

SUMMARY BY MONTHS FOR 1898.

	Temperature.											Number of days.						
	Mean.	Highest.	Date.	Lowest.	Date.	Range.	Mean daily range.	Greatest daily range.	Date.	Least daily range.	Date.	Clear.	Fair.	Cloudy.	Rain fell .01 or more.	Monthly rainfall.	Average daily rainfall.	Prevailing direction wind.
At the Station —																		
January	31.6	64.	13	—1	2	65	15	32	13	5	21	1	6	24	12	4.10	.13	W.
February	27.4	64.	11	—9	*1	73	16	31	17	6	*2	2	8	18	13	2.27	.07	S. W.
March	43.3	71.	19	12	1	59	21	35	7	5	2	10	10	11	15	6.44	.21	S. E.
April	45.3	77.	17	16	3	61	22	37	12	9	2	9	10	11	10	2.56	.09	N.
May	58.3	81.	21	32	9	49	22	48	*3	10	3	12	12	7	18	4.60	.15	N.
June	68.7	90.	30	40	22	50	25	35	1	14	*4	20	10	0	8	2.70	.09	N.
July	74.5	96.	3	45	10	51	24	42	13	14	*5	16	12	3	9	6.70	.22	S.
August	71.1	90.	*6	46	28	44	20	33	*7	9	18	13	12	6	12	5.53	.18	S.
September	66.2	90.	*8	38	12	52	24	38	20	10	23	23	4	3	7	2.15	.07	S.
October	52.6	86.	3	24	29	62	20	36	10	3	*9	11	7	13	12	4.28	.14	S. E.
November	38.4	66.	4	13	27	53	20	50	14	6	15	7	6	17	10	4.14	.14	S. W.
December	27.9	56.	*10	1	14	55	15	32	29	5	18	9	7	15	13	2.29	.07	S. W.
Sums and averages	50.4	78.	......	21	......	56.1	20.3	36.6	......	8	......	133	104	128	134	3.99	.13	N.-S. W.
For the State —																		
January	32.4	71.	12	—18	2	89	......	45	4	......	......	6	6	19	12	5.25	.16	S. W.
February	30.0	72.	11	—20	3	92	......	48	4	......	......	6	8	14	10	2.32	.08	S. W.
March	45.0	84.	22	5	*1	79	......	48	12	......	......	10	7	14	13	6.23	.19	S.
April	47.2	87.	30	10	3	77	......	49	12	......	......	12	9	9	7	2.38	.07	N.
May	61.0	92.	21	29	9	83	......	48	12	......	......	11	11	10	13	4.10	13	S. W.
June	71.9	99.	7	39	*2	60	......	51	24	......	......	17	10	3	8	2.86	10	S. W.
July	76.0	105	1	38	11	94	......	49	6	......	......	15	12	4	8	3.98	.13	S. W.
August	73.5	100	31	40	28	60	......	46	28	......	......	13	11	6	9	4.50	.14	S. W.
September	67.8	102	1	38	12	69	......	53	12	......	......	17	9	5	7	2.56	.09	S. W.
October	53.1	96	4	20	28	76	......	48	28	......	......	10	8	13	11	3.72	.12	S. W.
November	38.8	76	3	2	28	74	......	49	3	......	......	10	8	13	9	3.17	.11	S. W.
December	28.8	67	29	—18	14	85	......	47	*2	......	......	10	7	14	9	2.71	.09	S. W.
Sums and averages	52.1	88	......	14	......	78.1	......	48.4	......	......	......	137	106	124	116	3.65	.12	S. W.

Station *1 2—3. *2 5—13. *3 9—18. *4 27—28. *5 11—31. *6 23—21. *7 28—29. *8 1—2—3. *9 5—31. *10 22—29.
State *1 1—3. *2 3—22—23.

METEOROLOGY — TABLE VII.

SUMMARY BY YEARS AND GRAND SUMMARY FOR ELEVEN YEARS AT WOOSTER.

	1888.	1889.	1890.	1891.	1892.	1893.
At	Wooster.	Wooster.	Wooster.	Wooster.	Wooster.	Experiment Station.
Mean temperature	47.3°	48.6°	49.5°	49.6°	48°	48.7°
Highest temperature		[1] 91.5°	94.5° Aug. 3	99° Aug. 8	98° July 25.	[5] 95.°
Lowest temperature	—5° Feb. 9.	[2] —5.°	1° March 7.	0° March 1.	—20° Jan. 20.	—9° Jan. 11.
Range of temperature		96.5°	93.5°	99°	118°	104°
Mean daily range of temperature		18.7°	18.9°	21°	19°	20.2°
Greatest daily range of temperature		42° April 23	41° Jan. 13.	42° Sept 23	46° July 7.	45° Aug. 9.
Least daily range of temperature		2° Jan. 6	[3] 4.51°	4° Feb. 8	[4] 4.°	[6] 8.°
Number of clear days		125	109	116	116	96
Number of fair days		103	119	110	123	164
Number of cloudy days		137	137	125	98	105
Number of days rain fell		119	149	119	119	129
Total rainfall	38.23 inches.	39.87 inches.	54.21 inches.	38.36 inches	41 46 inches.	40 61 inches.
Greatest monthly rainfall	4.54 inches.	6.73 in.—July.	7.45 in.—Oct.	4.26 in.—June.	7 89 in.—June.	6.33 in.—Feb.
Least monthly rainfall	1.39 inches.	1.36 in.—Oct.	1.74 in.—Dec.	1.95 in.—April.	1.37 in.—Oct.	1 38 in.—July.
Prevailing direction of wind	S	S.	S	S	S. W	S. W.

[1] July 10. Sept. 1. [2] Feb. 23 and 24. [3] Jan. 8 and Sept. 10. [4] March 5.—Nov. 1-3-25 and Dec. 1-18. [5] July 7-25 and Sept. 7. [6] Jan. 24.—Feb. 11 and May 26.

METEOROLOGY — TABLE VII.— Concluded.

SUMMARY BY YEARS AND GRAND SUMMARY FOR ELEVEN YEARS AT WOOSTER.

	1894.	1895.	1896.	1897.	1898.	Summary for eleven years.
At	Experiment Station.	Experiment Station.	Experiment Station.	Experiment Station.	Experiment Station.	
Mean temperature	50.6°	47 8°	49.6°	49.4°	50.4°	49.0
Highest temperature	98.° July 19.	98 ° June 4	93.° Aug. 9.	*10 96 °	96.° July 3	[illegible] Aug. 8, 1891.
Lowest temperature	—7.° Dec. 28	*8 —6 °	—6.° Feb. 19.	—18.° Jan. 26.	—9 ° Feb. 2.	—20.° Jan. 20, 1892.
Range of temperature	105.	104.°	99.°	114.°	105.°	119.°
Mean daily range of temperature	22.9°	21.8°	19.°	21 5°	20.3°	20.3
Greatest daily range of temperature	45.° July 31.	55.° Oct. 6.	43 ° May 8.	49.° Oct. 5.	50.° Nov. 11.	55.° Oct. 6, 1895.
Least daily range of temperature	*7 4.°	1.° Nov. 27	*9 3.°	0.° Feb. 6.	*11 5 °	0.° Feb. 6, 1897.
Number of clear days	127	125	130	124	133	120
Number of fair days	154	117	106	123	104	122
Number of cloudy days	84	123	130	115	128	118
Number of days rain fell	130	102	134	128	134	126
Total rainfall	30.60 inches.	31 45 inches.	38.47 inches.	36.16 inches.	47.85 inches	39 75 inches.
Greatest monthly rainfall	4.41 in.—May.	4.21 in.—Nov.	8.05 in.—July.	5.76 in.—Nov.	6.79 in.—July.	8.05 in.—July, 1896.
Least monthly rainfall	0.76 in.—Aug.	1.00 in.—Feb.	0.71 in.—Oct.	0.29 in.—Sept.	2.15 in.—Sept.	.29 in.—Sept., 1897.
Prevailing direction of wind	S. W.	N.	S. W.	N. W	N.—S. W.	S. W.

*7 Dec. 1-23. *8 Jan. 12-13 and Feb. 5. *9 Jan. 10 and March 8. *10 July 5-6. *11 Jan. 21, March 2, Dec. 18.

METEOROLOGY — TABLE VIII.

SUMMARY BY YEARS AND GRAND SUMMARY FOR SIXTEEN YEARS FOR THE STATE.

	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.
Mean temperature......	49.4°	50.6°	48.°	49.6°	51.4°	49.5°	51.1°	52.4°	52.°
Highest temperature................	98.° Aug. 22.	99.° Sep.28, Oct.1.	101.° July 21.	98.6° July 7.	108.° July 18.	102.° Aug. 3.	99.5° Aug. 31.	103.1° Aug. 3.	101.° Aug. 10.
Lowest temperature......	—17.2° Jan 22.	—34.° Jan. 25.	—31.° Jan. 29.	—21.5 Jan. 7.	—21.° Jan. 17.	—15.° Jan. 27.	—13.5° Feb. 24.	—4.° Mar. 7.	—5.° Mar. 5.
Range of temperature..	115.5°	133.°	132.°	120.1°	129.°	117.°	113.°	107.1°	106.°
Mean daily range of temperature....	19.8°	20.5°	20.4°	20.2°	21.2°	19.6°	19.3°	19.°	20.°
Greatest daily range of temperature	55.2° March 18.	50.° Sep.5, Dec 4.	58.5° Jan. 30.	57.° Dec. 11.	57.° April 11.	50.°	53.° Mar. 30.	49.5° Ap. 11.	50.° Ap. 27-30.
Least daily range of temperature....	0.5° Dec. 23.	1.1° Feb. 6.	1.° Ap.18, Dec.31.	1.1° March 27.	1.° Jan.5, Ap.16	1.2° Jan. 16.	1.° Jan. 5.	1.° Dec. 17.	2.° Jan. 2.
Average number of clear days.......	98	117	104	118	114	109	113	103	133
Average number of fair days	135	118	133	126	127	123	114	122	109
Average number of cloudy days.....	130	131	128	121	124	134	138	140	137
Average number of days rain fell....	146	145	148	131	121	125	115	149	120
Mean yearly rainfall..	44.98 inches.	40.19 inches.	30.08 inches.	37.71 inches.	33.6 inches.	39.64 inches.	33.53 inches.	50.33 inches.	38.61 inches.
Mean daily rainfall..................	0.123 inch	0.110 inch.	0.104 inch.	0.100 inch.	0.092 inch.	0.108 inch.	0.092 inch.	0.138 inch.	0.110 inch.
Prevailing direction of wind.........	S. W.........	S. W.........	S. W.........	S. W.........	S. W........	S. W.... ...	S. W..... ..	S. W........	S. W........

METEOROLOGY — TABLE VIII.— Concluded.

	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Summary for sixteen years.
Mean temperature	50.°	50.10°	52.40°	49.9°	51.8°	50.6°	52.0°	50.7°
Highest temperature	103.° July 25.	102.° June 19.	105.° July 18-19.	106.° July 20.	103.° April 17.	113.° July 4.	105.° July 1.	113.° July 4, 1897.
Lowest temperature	—25.° Jan. 20.	24 °	—27.° Dec. 29.	—24.° Feb. 6.	—18.° *4	—27.° Jan. 26.	—20.° Feb. 3.	—34.° Jan. 25, 1884.
Range of temperature	128.°	126.°	132.°	130.°	121.°	140.°	125.°	117.1°
Mean daily range of temperature	19.°	21.7°	23.°	23.4°	20.°	....	....	....
Greatest daily range of temperature	51.° Sept. 25.	54.6°	60.° Oct. 19.	59 ° *3	53.° Mar. 25.	67.° Sept. 25 26.	....	....
Least daily range of temperature	1.° *2	1.°	1.° Feb. 7.	0.° Feb. 7	0 ° *5	....	....	....
Average number of clear days	111	122	138	143	118	130	130	118
Average number of fair days	126	123	126	119	130	119	110	122.5
Average number of cloudy days	129	120	101	103	118	116	125	124.7
Average number of days rain fell	121	113	100	89	124	110	121	123.6
Mean yearly rainfall	37.16 inches.	39.63 inches.	29.75 inches.	28 46 inches	39.58 inches.	38 54 inches.	43.78 inches	37.85
Mean daily rainfall	0.100 inch.	0.110 inch.	0.080 inches.	0 007 inch	0.12 inch.	0.10 inch.	0.119 inch	0.99
Prevailing direction wind	S. W.	S. W.	S. W.	S. W	S. W.	S. W.	S. W	S. W.

*1 Jan. 4 and 11, March 19 and 22, Nov. 12, and Dec. 4. *2 July 29, Nov. 3–12 and 28, Dec. 17. *3 Jan. 15, March 29. *4 Feb. 9, 10, 11. *5 Jan. 10, March 8.

INDEX.

PUBLICATIONS OF THE OHIO EXPERIMENT STATION.

The first six annual reports of this Station. for the years 1882 to 1887, inclusive, contain the full record of its work during that period. Such bulletins as were published during these years ("First Series") were intended for newspaper use; they were afterward incorporated in the annuals and no copies of the bulletins can now be furnished. The first and second annual reports are also out of print.

The "Second Series" of bulletins began with 1888. The first seven of these were included in the seventh annual report, and cannot be furnished separately. The bulletins published since 1888 are listed below:

No. 8 (Vol. II, No. 1, 1889) — Insects, insecticides and methods of collecting and studying insects. *Out of print.*

No. 9 (Vol. II, No. 2, 1889) — Colic of horses. *Out of print.*

No. 10 (Vol. II, No. 3, 1889) — Silos and ensilage. Silage and field beets as food for cows. *Out of print.*

No. 11 (Vol. II, No. 4, 1889) — Experiments with small fruits. Effects of early and late picking upon keeping quality of apples. *Out of print.*

No. 12 (Vol. II, No. 5, 1889) — Wheat: Cultural and variety tests. *Out of print.*

No. 13 (Vol. II, No. 6, 1889) — Remedies for plum curculio and striped cucumber beetle. Notes upon strawberry root-louse, grain plant-louse and little known injurious insects. Prevention of potato rot. *Out of print.*

No. 14 (Vol. II, No. 7, 1889) — Cabbage and cauliflower, and treatment of certain plant diseases. *Out of print.*

No. 15 (Vol. II, No. 8, 1889) — Eighth annual report. Meteorological summary. Index.

No. 16 (Vol. III, No. 1, 1890) — Experiments with potatoes.

No. 17 (Vol. III, No. 2, 1890) — Field experiments with fertilizers.

No. 18 (Vol. III, No. 3, 1890) — Experiments with corn and oats. Actinomycosis.

No. 19 (Vol. III, No. 4, 1890) — Spraying to prevent insect injury. Insects affecting corn. Fungous diseases of plants. Collecting plants.

No. 20 (Vol. III, No. 5, 1890) — Corn silage vs. sugar beets as food for milk production.

No. 21 (Vol III, No. 6, 1890) — Wheat: Cultural and variety tests.

No. 22 (Vol. III, No. 7, 1890) — Strawberries and raspberries.

No. 23 (Vol. III, No. 8, 1890) — The plum curculio, cucumber bettle, rhubarb curculio and clover stem borer. Potato blight.

No. 24 (Vol. III, No. 9, 1890) — Asparagus. Transplanting onions.

No. 25 (Vol. III, No. 10, 1890) — Grape rot and corn smut.

No. 26 (Vol. III, No. 11, 1890) — Ninth annual report. Meteorological summary. Index.

No. 27 (Vol. IV, No. 1, 1891) — Corn: Cultural, variety and fertilizer tests.

No. 28 (Vol. IV, No. 2, 1891) — Miscellaneous experiments in the control of injurious insects.

No. 29 (Vol IV, No. 3, 1891) — Fertilizers on wheat. *Out of print.*

No. 30 (Vol. IV, No. 4, 1891) — Wheat: Cultural and variety tests and treatment for smut.

No. 31 (Vol. IV, No. 5, 1891) — The wheat midge.

No. 32 (Vol. IV, No. 6, 1891) — Experiments with small fruits. Diseases of the raspberry and blackberry.

No. 33 (Vol. IV, No. 7, 1891) — The Hessian fly.

No. 34 (Vol. IV, No. 8, 1891) — Forty years of wheat culture in Ohio.

No. 35 (Vol. IV, No. 9, 1891) — Apple scab. The spraying of orchards. *Out of print.*

No. 36 (Vol. IV, No. 10, 1891) — Tenth annual report. Meteorological summary. Index.

No. 37 (Vol. V, No. 1, 1892) — Oats: Cultural and variety tests.

No. 38 (Vol. V, No. 2, 1892) — Mangel wurzels and sugar beets.

No. 39 (Vol. V, No. 3, 1892) — Fertilizers on corn and oats.

No. 40 (Vol. V, No. 4, 1892) — Insects which burrow in the stem of wheat.

No. 41 — Not published.

No. 42 (1892) — Wheat: Cultural and variety tests.

No. 43 (1892) — Greenhouses and greenhouse work. The food of the robin.

No. 44 (1892) — The rusts of Ohio. Wild lettuce. Scab of wheat.

No. 45 (1892) — Insects affecting the blackberry and raspberry.

No. 46 (1892) — Underground insect destroyers of the wheat plant.

No. 47 (1892) — Eleventh annual report. Meteorological summary. Index.

No. 48 (1893) — Profit in spraying orchards and vineyards. *Out of print.*

No. 49 (1893) — Field experiments with fertilizers.

No. 50 (1893) — Experiments in feeding for milk.

No. 51 (1893) — Miscellaneous entomological papers.

No. 52 (1893) — Twelfth annual report. Meteorological summary. Index.

No. 53 (1894) — Field experiments with commercial fertilizers.

No. 54 (1894) — Strawberries. *Out of print.*

No. 55 (1894) — The Russian Thistle in Ohio.

No. 56 (1894) — The San Jose Scale.

No. 57 (1894) — Oats: Variety and cultural experiments.

No. 58 (1894) — Thirteenth annual report. Meteorological summary. Index.

No. 59 (1895) — Noxious weeds along thoroughfares and their destruction.

No. 60 (1895) — Feeding for beef.

No. 61 (1895) — Sub-irrigation in the greenhouse.

No. 62 (1895) — The grape-root worm.

No. 63 (1895) — Orchard spraying and notes on varieties of raspberries.

No. 64 (1895) — The smut of oats.

No. 65 (1895) — Variety trials with potatoes.

No. 66 (1895) — Fourteenth annual report. Meteorological summary. Index.

No. 67 (1896) — Oats: Variety and cultural experiments; treatment for smut.

No. 68 (1896) — Some destructive insects.

No. 69 (1896) — The chinch bug.

No. 70 (1896) — Forage crops.

No. 71 (1896) — The maintenance of fertility. Field experiments with fertilizers.

No. 72 (1896) — Peach Yellows, Black Knot and San Jose Scale.

No. 73 (1896) — Investigations of plant diseases in forcing house and garden.

No. 74 (1896) — Fifteenth annual report. Meteorological summary. Index.

No. 75 (1897) — Beet sugar production.

No. 76 (1897) — Potatoes: Cultural notes and variety and fertilizer tests.

No. 77 (1897) — The chinch bug and other destructive insects.

No. 78 (1897) — Corn: Cultural and variety tests. Corn smut.

No. 79 (1897) — Some diseases of orchard and garden fruits.

No. 80 (1897) — The maintenance of fertility. Field experiments with fertilizers.

No. 81 (1897) — The San José scale in Ohio.

No. 82 (1897) — Wheat: Cultural and variety tests.

No. 83 (1897) — A first Ohio weed manual.

No. 84 (1897) — Sixteenth annual report. Meteorological summary. Index.

No. 85 (1897) — Strawberries: Cultural notes and variety tests.

No. 86 (1897) — The story of the lives of a butterfly and a moth.

No. 87 (1897) — The Periodical Cicada, or so-called Seventeen-year Locust, in Ohio.

No. 88 (1897) — Co-operative experiments made by the Ohio Agricultural Students' Union in 1896.

No. 89 (1897) — Prevalent diseases of cucumbers, melons and tomatoes.

No. 90 (1898) — Sugar beet investigations in 1897.

No. 91 (1898) — The lung and stomach worms of sheep.

No. 92 (1898) — Preliminary report upon diseases of the peach. Experiments in spraying peach trees.

No. 93 (1898) — The home-miving of fertilizers.

No. 94 (1898) — The maintenance of fertility. Field experiments with fertilizers in 1897.

No. 95 (1898) — Seventeenth annual report. Meteorological summary. Index.

No. 96 (1899) — The Army Worm and Other Insects; Wheat and Grass Saw-flies; the Corn or Boll Worm; the Painted Hickory Borer; the Raspberry Cane Borer; the Peach Scale.

No. 97 (1899) — Diseases of wheat and oats.

No. 98 (1899) — Small fruits; cultural notes and comparison of varieties.

No. 99 (1899) — Sugar beet investigations in 1898.

No. 100 (1899) — A comparison of factory-mixed and home-mixed fertilizers.

No. 101 (1899) — Experiments with oats.

No. 102 (1899) — Soil and seed treatment and spray calendar for insect pests and plant diseases.

No. 103 (1899) — The San Jose Scale in Ohio.

No. 104 (1899) — Further studies upon spraying peach trees and upon diseases of the peach.

No. 105 (1899) — Further studies of cucumber, melon and tomato diseases.

No. 106 (1899) — I. The chinch bug. II. Experiments with insecticides.

No. 107 (1899) — The Hessian Fly.

No. 108 (1899) — Bovine Tuberculosis.

No. 109 (1899) — Eighteenth annual report. Meteorological summary. Index.

This Station has also published four bulletins in a "Technical Series," the first three numbers of which are devoted to entomological and botanical papers, the last to a list of the birds of Wayne county, Ohio.

Ohio Agricultural Experiment Station.

BULLETIN 110.

WOOSTER, OHIO, DECEMBER, 1899.

THE MAINTENANCE OF FERTILITY.

FIELD EXPERIMENTS WITH FERTILIZERS,

1888 to 1899.

The Bulletins of this Station are sent free to all residents of the State who request them. Persons who wish their address changed should give both old and new address. All correspondence should be addressed to

EXPERIMENT STATION, WOOSTER, OHIO.

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1899

BULLETIN 110

OF THE

Ohio Agricultural Experiment Station.

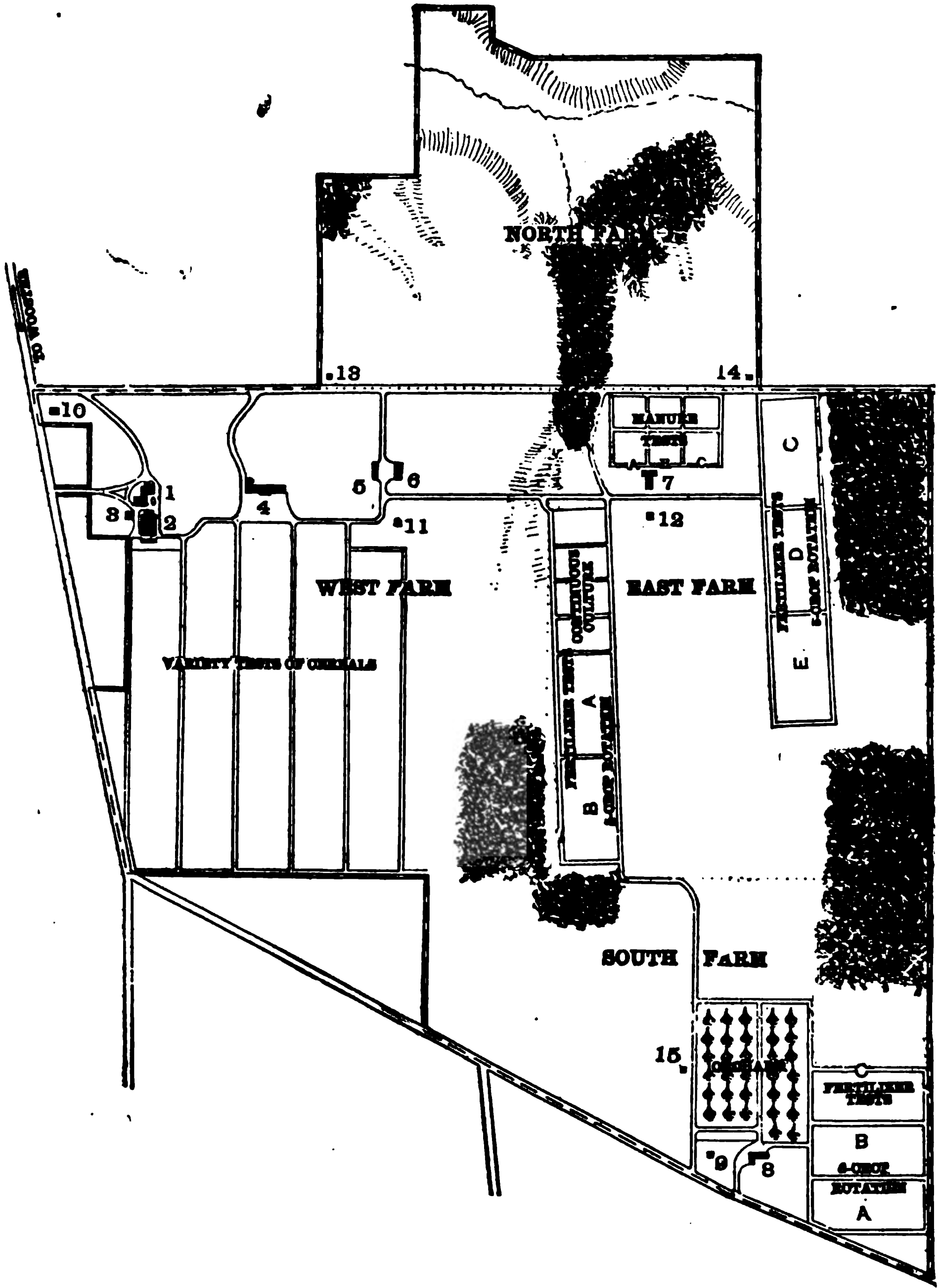
Wooster, Ohio, U. S. A., December, 1899.

THE MAINTENANCE OF FERTILITY.

CONTENTS.

Main Building. Chemical Laboratory. Biological Laboratory.

OHIO AGRICULTURAL EXPERIMENT STATION.



FARM MAP—OHIO AGRICULTURAL EXPERIMENT STATION.

1. Main building.
2. Greenhouses.
3. Biological laboratory.
4. Dairy barn and creamery.
5. Tool house.
6. Horse barn.
7. East barn.
8. Horticultural barn and cold storage.
9. Residence of Horticulturist.
10. Residence of Director.
11, 12, 13, 14, 15. Dwellings occupied by foremen and laborers.

Bul. 110

ORGANIZATION OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

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Cary Welty	"	Mechanic
Edward Mohn	Strongsville	Supt. Northeastern Sub-Station
Lewis Schultz	Neapolis	Supt. Northwestern Sub-Station

The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 110. DECEMBER, 1899.

THE MAINTENANCE OF FERTILITY.

BY C. E. THORNE.

INTRODUCTORY.

The investigations reported in the following pages have been conducted, in general outline, upon plans adopted at a conference of experiment station workers, held in Washington, D. C., in March, 1888. For the general oversight of the work and for the discussion of results the Director of the Station is responsible, but it is his very pleasant duty to acknowledge that, in the execution of the work, there has been the most hearty coöperation on the part of all the members of the staff of the Station within whose special departments any portion of it was found.

During the twelve seasons over which these experiments have been continued the Agriculturist of the Station, Prof. J. F. Hickman, has had the immediate supervision of the field experiments upon cereal and hay crops, assisted during the entire period by William Holmes, and for the last nine years by C. A. Patton, Farm Foremen. Prof. W. J. Green, Horticulturist, has conducted the experiments upon potatoes throughout the twelve seasons, and for the last six years Prof. A. D. Selby, Botanist and Chemist, has rendered assistance in the chemical examination of the soils under test and of the fertilizing materials employed. For six years Mr. Edward Mohn has executed the experiments at the Northeastern Substation, at Strongsville, and for two years Mr. Lewis Schultz has performed similar services at the Northwestern Substation, at Neapolis.

Partial reports of this work have been made in the Seventh Annual report of this Station and in Bulletins 17, 27, 29, 39, 49, 53, 71, 80, 93 and 94; but it seems desirable at present to publish a more complete record of the work than has yet been done. If some of the details given should seem superfluous to the reader who cares only for the main results of

the test, it is hoped that they may be found not without value to the scientific investigator.

These investigations have been planned and conducted with a view to obtaining light upon the following points:

1. The relative importance, both to the soils and to the crops under test, of nitrogen, phosphoric acid and potash in the fertilizer.

2. The ratio to each other in which these leading constituents of the fertilizer may be most profitably used.

3. The forms or carriers in which they may be most cheaply and effectively given to the soil.

4. The extent to which the demand for nitrogen in the fertilizer may be satisfied by the culture of clover.

5. The capacities of different species of crop-plants for securing their own supplies of plant food.

6. The proportion of plant-food applied in manure and fertilizers which may be recovered in the crops grown upon them.

In the pursuit of this research the Station is now employing nearly 900 permanently located plots, chiefly one-tenth acre in size, lying in part upon its farm near Wooster, and in part upon other tracts of land, leased for this purpose in different parts of the state.

The soils under test range from dune sand to the heaviest clay, and from land newly cleared from the forest, to that which has been robbed of its natural fertility by three-quarters of a century of an exhaustive system of husbandry.

In selecting these soils great care has been exercised to secure uniformity in character, topography and previous history of soil for each separate test. Land with a slight incline has been taken in preference to that which is absolutely level, as the excess of water collected in the slight depressions of level land tends to obscure results. Except on the dune sand and on the soil at East Liverpool, which is almost as pervious to water as the sand, all the plots have been slightly ridged in order the more uniformly to dispose of surface water and to prevent it from washing across the plots; and, with the same exceptions, and one other tract of about two acres of land, newly cleared from the forest, all the land in these experiments has been underdrained with tile drains, laid 36 feet apart and 30 inches in depth.

The land in these experiments has been laid out in plots of one-tenth, one-sixteenth or one-twentieth acre, chiefly of the larger size. The plots are 16 feet wide—this being a convenient width for our seeding and harvesting machinery—with dividing spaces 2 feet wide. The tile drains are laid under alternate dividing spaces, so that every plot has a tile drain on one side or the other. The plots are arranged in blocks of 8 or 10, and roadways 12 feet wide are left between these blocks to facilitate harvesting when, as sometimes happens, it is necessary to cut but one way, and also for convenience in hauling in the grain, as it is necessary to

avoid the repeated passing of wagons or machines over land used in experiments.

The crops employed in these tests are corn, oats, wheat, clover, timothy and potatoes; soy beans being sometimes substituted for clover in case of failure to secure a stand of the latter crop. The cereal crops, corn, oats and wheat, are grown both continuously and in rotation. Three rotations are in progress, one of corn, oats and wheat, one year each, followed by clover and timothy, two years; one of potatoes, wheat and clover, one year each, and one of corn, wheat and clover, one year each. The fertilizers are applied altogether upon the cereal and potato crops; the clover and timothy follow as gleaners.

Wherever possible, machinery is used in the planting, cultivating and harvesting of the cereal and hay crops, as the work can be more uniformly and more accurately done by machinery than by hand. The fertilizers are distributed by the fertilizer drill, for corn as well as for oats and wheat; the fertilizers for all the plots of an experiment being mixed to a uniform bulk with sand, so that all may be distributed with one setting of the drill. The manure is applied with the manure spreader. For all crops the fertilizers are distributed just before planting. The corn is planted with the double check-rower, and the oats and wheat with grain drills In sowing the small grains the space sown is a few feet longer at each end than the actual plot, and is cut back to the proper length at a later date. This is done to avoid the blanks caused by the time required for the seed to run from the hopper to the ground.

All the plots are permanently marked by iron stakes, which are set either at the corners of each plot or at those of each block, the stakes being driven to the surface of the ground so that machinery can pass over them. In planting corn, or drilling oats or wheat, a stake is set at the proper distance from the corner of the plot and the planter or drill is driven to this stake, the driver sighting over the end of the tongue. The drivers are expected to make straight rows, whether with planter or drill.

The corn is cultivated with double cultivators, ample space for turning the team (14 to 20 feet) being left at the ends of the plots. Level-working cultivators are used.

The oats and wheat are harvested with automatic binders. In cutting, a man follows the machine constantly, to see that every sheaf falls upon its proper plot, and to clean off any parts of bundles at the ends.

The corn is cut and husked by hand. The total stalks, barren stalks, ears and nubbins are counted, and the ears and nubbins are weighed separately.

The oats and wheat are threshed from the shock. Several plots are hauled in at a single load, sheets being used to separate them. The total weight of the load is taken on ordinary wagon scales; a plot is thrown off to the thresher, the load is weighed again, and so on until it is all off.

Great care is taken in threshing to insure the most accurate separation possible of the grain from the different plots. The grain is weighed from the thresher into labeled sacks and held until opportunity is had to verify the weights.

In harvesting the hay the mowing machine is driven to stakes, just as the planter and drill are in planting, the grass growing in the dividing spaces being left until after the hay on the plots is cured, weighed and hauled away. The hay has hitherto been loaded on slings, one plot to a sling and several slings to a load, the wagon being run out of the barn and weighed again after unloading each plot. A more satisfactory way, recently adopted, is to weigh the slings, either on apparatus adjusted to the track in the barn, or on a portable derrick in the field.

The potatoes have thus far been planted by hand and harvested with the help of a shovel plow, or digger of that type. They are weighed in the field, then taken to the barn, assorted into large and small and weighed again.

THE SOILS UNDER EXPERIMENT.

This work is now in progress in five sections of the state, namely:

1. At the Experiment Station, at Wooster; the soil here is a yellow, somewhat sandy clay, lying upon the upper rocks of the Waverly series; it is of glacial drift origin, but is largely modified by the soft, sandy shales upon which it lies, and which have been ground up and mixed with materials derived from granites and limestone to the northward. The native rock is abundantly streaked with iron, and a liberal percentage of iron is found in the soil, as shown by its analysis.

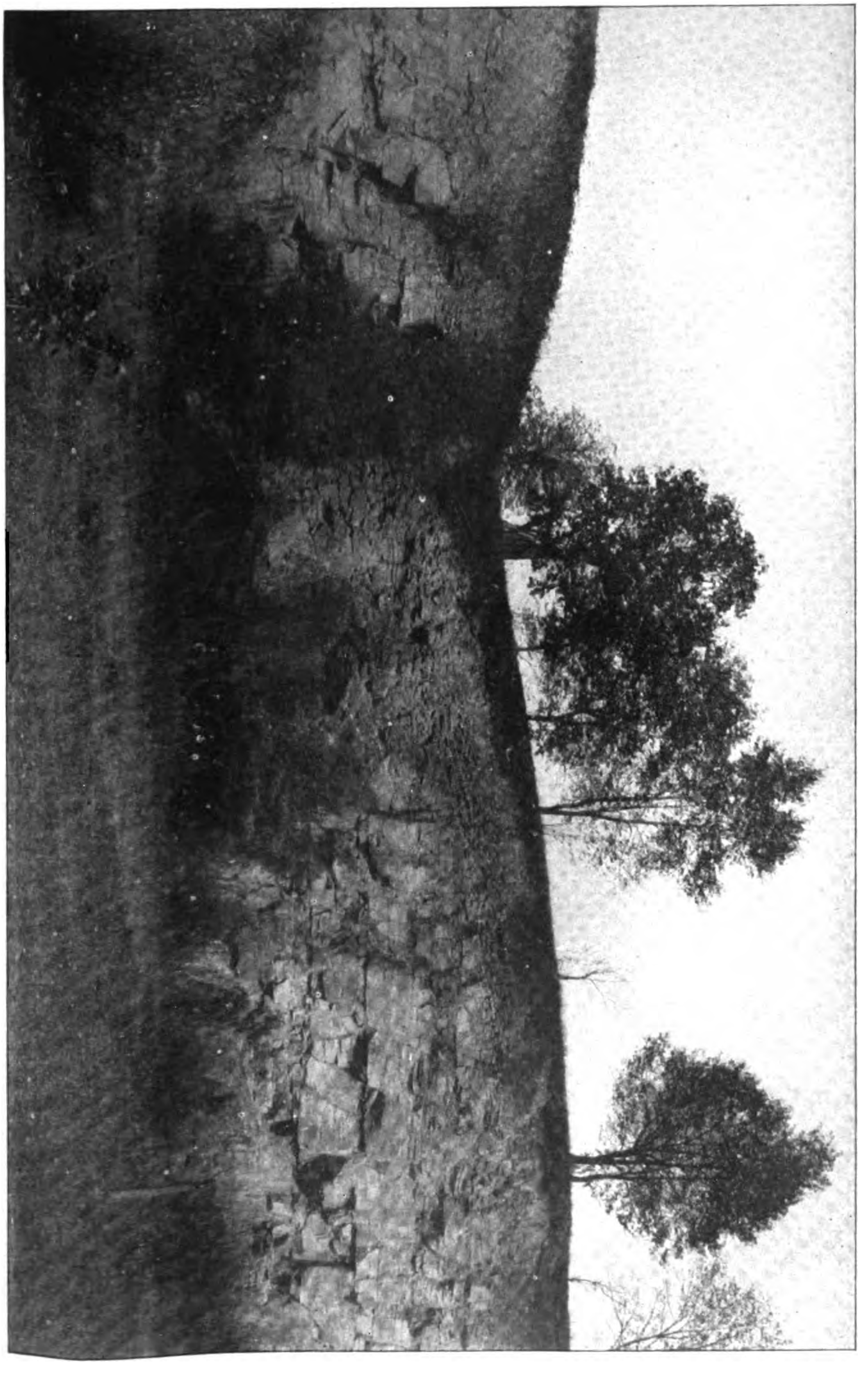
The original forest growth of this region was chiefly white oak, (*Quercus alba* L) with a little admixture of red, scarlet and black oaks, and an occasional chestnut (*Castanea vesca* L.). The most striking arboreal feature is the thick undergrowth of Dogwood (*Cornus florida* L.) which belts the forest with its white blossoms in early May.

The topography of the country is rolling, due entirely to erosion, as the rocks lie in level strata. When the forest was cleared away the slowly decaying roots of the deep-rooting White Oak furnished channels of drainage, through the thin sheet of clay, to the loosely stratified rocks below, and through their rifts and seams the drainage waters precolate, to feed the multitude of springs for which the region is famous. But as the roots decayed more completely the plow and the trampling of teams and pastured stock obliterated these natural channels, and artificial drainage became necessary.

In one of the fields a large system of tile drains has been led into a cistern or well, dug deeply into the shaly rock below, and which serves as a complete outlet to the drains.

2. Corn, oats and wheat are being grown in continuous culture on the farm of the Ohio State University at Columbus. The soil here is a

PLATE I.



"The rocks lie in level strata * * * and through their rifts and seams the drainage waters percolate, to feed the springs for which this region is famous."

much heavier clay than that at Wooster, lying in part upon the Huron shale and in part upon alluvial gravels. Twenty-two plots of one-tenth acre each are devoted to each crop. The work was begun in 1888 and is continued by coöperation between the Farm Department of the University and the Experiment Station.

3. An experiment in the continuous culture of corn on the same land has been carried on since 1888 near East Liverpool, Columbiana county, by coöperation between the owner of the land and the Station. The soil there is a thin clay; the underlying rock a porous shale belonging to the coal measures.

4. A sub-station, or test farm, for field experiments, was located in 1894 near Neapolis, about 20 miles west of Toledo, on the yellow, dune sands which mark the ancient beach of Lake Erie. The native forest here is a scrubby growth of White and Black Oaks, chiefly the latter. The timber was cleared from the land for this test, the bringing of this loose sand into profitable production being the chief problem here.

5. A similar sub-station was established in 1895 near Strongsville, about 12 miles southwest of Cleveland. The underlying rock here is the Cuyahoga shale, a gray, argillaceous shale, nearly impervious to water, which weathers into a cold, heavy, tenacious, white clay. Although this region lies within the glaciated area of the state, the underlying rock, which, in the case of this test farm, is usually less than 10 feet from the surface, is the chief source from which the soil has been derived. The native forest of this region consisted chiefly of Beech (*Fagus ferruginea* Ait.) and Elm (*Ulmus Americana* L.), with Sugar Maple (*Acer saccharinum* Wang.) on the better drained portions.

In Tables I and II are given the mechanical and chemical analyses of several of these soils. From these tables it will be seen that the soils at Wooster, Strongsville and Columbus show considerable similarity in physical constitution, the most marked difference being the larger proportion of clay in the Strongsville soil. In the Neapolis soil, however, the excess of sand and deficiency of silt and clay are marked. Comparing the Neapolis with the Wooster and Strongsville soils, it will be seen that the average size of the soil particles is approximately ten times as great in the former as in the latter. The Columbus soil stands between these two classes in mechanical texture, but when we come to consider their chemical composition, as shown in Table II, we find that the soil last named is far richer in the chemical constituents of fertility than either of the others, while the sandy soil of the sub-station at Neapolis is relatively deficient.

These points are graphically brought out in Diagram I, which shows the relative proportions of phosphoric acid, potash, lime and magnesia found in the different soils. This diagram shows that the proportion of phosphoric acid is lowest in the soil at Wooster and highest in that at Strongsville; that lime and magnesia combined comprise nearly the same

TABLE I. MECHANICAL ANALYSIS OF SOILS UNDER EXPERIMENT.

Per cent of gravel, sand, silt and clay and loss on ignition, and diameter of soil particles in millimeters.*

Soils	Grav'l 2.0 to 1.0 mm.	Co'rse sand 1.0 to 0.5 mm.	Medium sand 0.5 to 0.25 mm.	Fine sand 0.25 to 0.1 mm.	Very fine sand 0.1 to 0.05 mm.	Silt 0.05 to 0.01 mm.	Fine silt 0.01 to 0.005 mm.	Clay 0.005 to 0.0001 mm.	Loss on ignition.
First six inches —									
Wooster, E. Farm	0.56	0.86	0.71	1.79	20.47	29.97	36.07	4.74	3.73
" S. Farm	0.37	0.93	0.65	1.00	17.19	30.92	40.39	3.47	3.76
Strongsville	2.27	2.34	1.93	4.31	10.74	23.14	38.36	8.59	5.41
Columbus	0.86	2.17	2.82	8.07	18.47	26.18	28.91	6.18	4.67
Neapolis	0.00	0.66	2.17	32.60	51.60	1.93	3.36	1.26	4.49
Second six inches —									
Wooster, E. Farm	1.27	1.49	0.93	2.35	16.84	32.21	34.18	6.15	3.40
" S. Farm	0.10	0.50	0.51	1.05	20.34	32.30	32.63	8.01	3.05
Strongsville	1.46	1.83	1.85	4.25	9.49	25.59	33.64	15.68	4.18
Columbus	0.68	2.06	2.69	8.38	18.30	26.27	28.81	7.16	4.36
Neapolis	0.00	0.64	1.85	30.93	56.09	1.52	2.95	2.53	2.53

*25.4 millimeters = 1 inch.

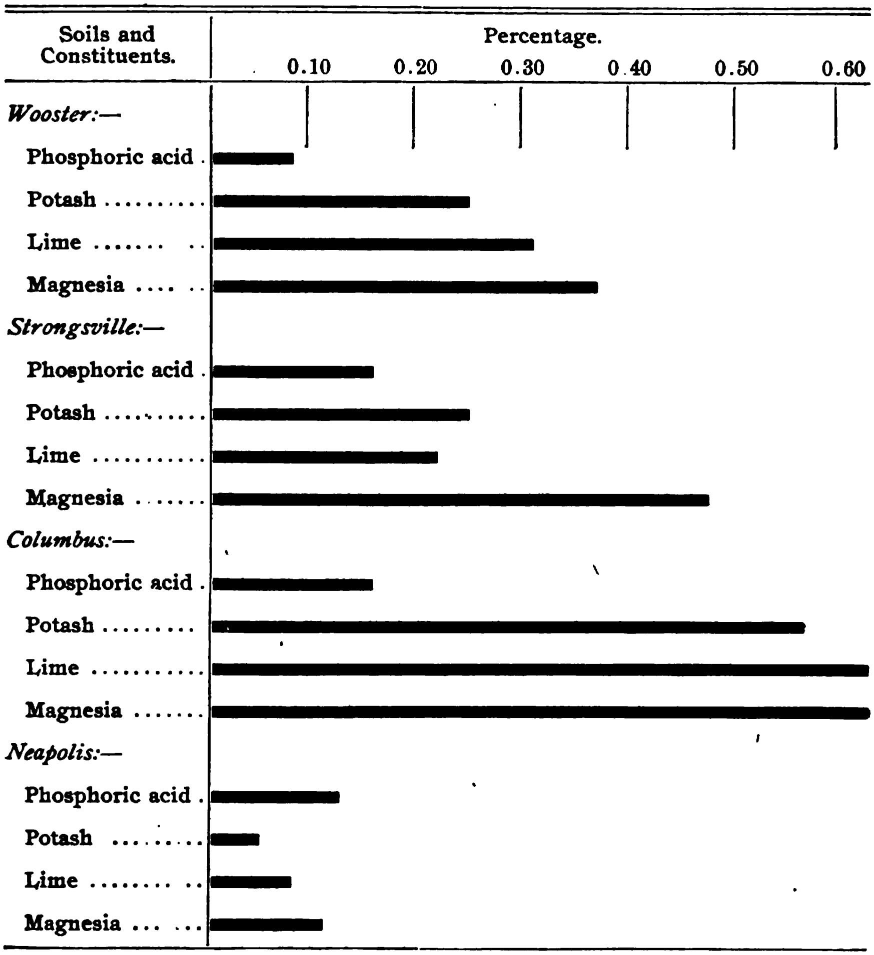
TABLE II. CHEMICAL COMPOSITION OF SOILS UNDER EXPERIMENT.

Percentage composition

Soils	Silica and insoluble matter	Potash (K_2O)	Soda (Na_2O)	Lime (CaO)	Magnesia (MgO)	Iron sesquioxide (Fe_2O_3)	Alumina (Al_2O_3)	Ph'sphoric acid (P_2O_5)	Sulphuric acid (SO_3)	Water and loss on ignition
Wooster, E. Farm—										
First 6 inches.....	88.713	.221	.393	.320	.361	2.643	2.533	.080	.044	4.481
Second 6 inches..	87.640	.278	.386	.307	.352	3.297	3.493	.080	.047	4.029
First 12 inches....	88.176	.250	.390	.313	.356	2.970	3.013	.080	.045	4.255
Strongsville —										
First 6 inches.....	85.045	.242	.145	.220	.432	3.010	2.535	.161	.055	7.937
Second 6 inches..	82.872	.260	.225	.190	.517	4.432	4.252	.129	.052	6.925
First 12 inches....	83.958	.251	.185	.205	.474	3.721	3.393	.145	.053	7.421
Columbus, O. S. U.—										
First 6 inches.....	83.437	.565	.739	.562	.619	3.409	4.858	.134	.089	5.869
Second 6 inches..	83.873	.562	.782	.689	.626	3.628	4.262	.152	.101	5.659
First 12 inches....	83.654	.563	.761	.621	.623	3.518	4.560	.143	.095	5.764
Neapolis —										
First 6 inches.....	92.090	.046	.060	.070	.100	1.000	1.100	.120	.030	5.130
Second 6 inches..	93.980	.040	.080	.070	.110	1.000	2.150	.110	.020	2.750
First 12 inches....	93.035	.043	.070	.070	.105	1.000	1.625	.115	.025	3.940

proportion of both these soils; that in the Columbus soil there is more than twice as much each of potash, lime and magnesia as is found at either Wooster or Strongsville, while the deficiency of the Neapolis soil in these constituents is strongly brought out.

DIAGRAM I. PERCENTAGE OF IMPORTANT SOIL CONSTITUENTS.

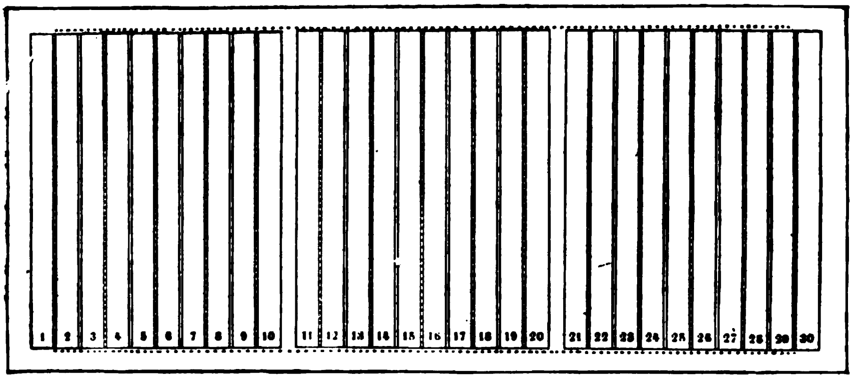


FERTILIZERS ON CROPS GROWN IN FIVE-YEAR ROTATION.

Diagram II shows the arrangement of one of the five sections, of 30 plots each, employed in the five-year rotation at Wooster. These sections, together with a similar section devoted to the continuous culture of corn, oats and wheat, 10 plots each, are arranged in two tiers, lying on the east and west sides of the "East Farm." It was not possible to locate them side by side, because of lack of suitable land. They occupy the

crests of two low ridges, running at a slight angle with the lines of the farm, as shown by the accompanying farm map.

DIAGRAM II. ARRANGEMENT OF PLOTS IN 5-YEAR ROTATION, WOOSTER.



In Diagram III is given the arrangement of the land devoted to the parallel test at Strongsville. Here a broad, uniform, gentle slope made it possible to arrange all the plots in a compact body.

Dotted lines indicate drains in this and following plans.

Table III shows the general plan of fertilizing in this rotation, and Table IV gives the total quantity of fertilizing materials applied per acre in the five years of a rotation, with estimated quantities of fertilizing constituents carried, and cost of total application. Superphosphate was used in the form of dissolved bone black previous to 1897, but since that date it has been given in acid phosphate, the 14 per cent. grade of Carolina acid phosphate being used in 1897 and 1898, and 16 per cent. Tennessee acid phosphate for the crops of 1899. When other carriers of phosphoric acid (wheat bran, slag meal, bone meal) are used the quantity applied is intended to carry the same quantity of phosphoric acid as that found in the standard dressing.

Nitrate of soda is used as the standard carrier of nitrogen, and is applied only in the spring. On corn, oats and potatoes it is used at the rate of 160 pounds per acre, and on wheat at the rate of 120 pounds, applied in April, and following a dressing of 40 pounds per acre of dried blood given in the fall. On Plot 12 in both tests the nitrate is increased to 240 pounds, and on Plots 35 and 36, at Strongsville, it is diminished to 80 and 40 pounds respectively.

Muriate of potash is used as the carrier of potash, and is applied uniformly at the rate of 80 pounds per acre on corn and oats and 100 pounds on wheat, except on Plots 17 and 21, where allowance is made for the potash in the bran and oil-meal; on Plot 30, where it is used at the

DIAGRAM III. ARRANGEMENT OF PLOTS IN 5-YEAR ROTATION, NORTH-EASTERN SUB-STATION, STRONGSVILLE.

Plots one-tenth acre.

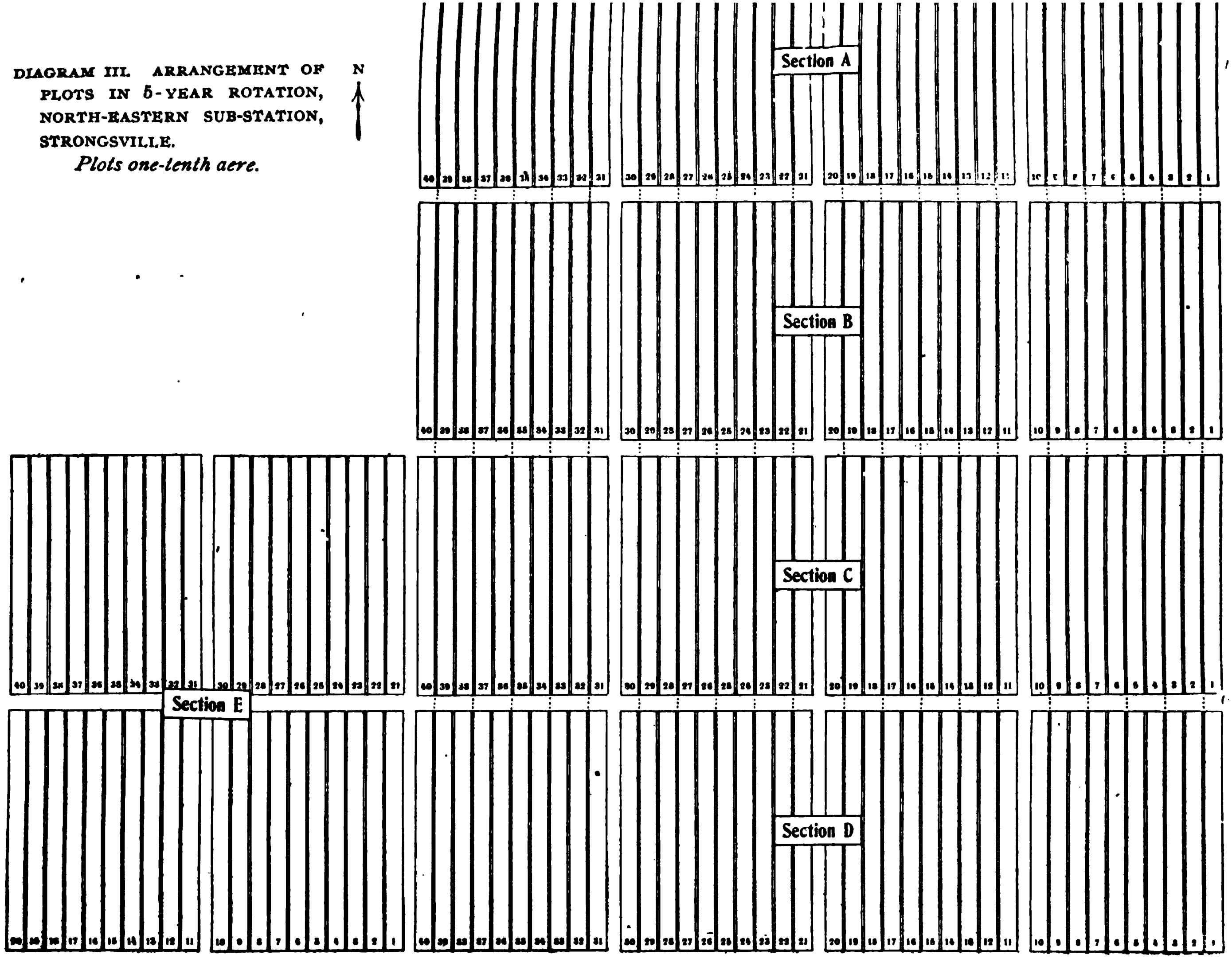


TABLE III. PLAN OF FERTILIZING IN 5-YEAR ROTATION

Fertilizers in pounds per acre.

Plot No.	On Corn			On Oats			On Wheat			
	Superphosphate 1	Muriate of potash	Nitrate of soda	Superphosphate 1	Muriate of potash.	Nitrate of soda	Superphosphate 1	Muriate of potash	Dried blood	Nitrate of soda 2
1	......	......	......	......	......	......	......	......	......	......
2	80	......	......	80	......	......	160	......	......	......
3	......	80	......	......	80	......	......	100	......	......
4	......	......	......	......	......	......	......	......	......	......
5	......	......	160	......	......	160	......	......	40	120
6	80	......	160	80	......	160	160	......	40	120
7	......	......	......	......	......	......	......	......	......	......
8	80	80	......	80	80	......	160	100	......	......
9	......	80	160	......	80	160	......	100	40	120
10	......	......	......	......	......	......	......	......	......	......
11	80	80	160	80	80	160	160	100	40	120
12	80	80	240	80	80	240	160	100	40	200
13	......	......	......	......	......	......	......	......	......	......
14	80	80	160	......	......	......	160	100	40	120
15	......	......	......	......	......	......	160	100	40	120
16	......	......	......	......	......	......	......	......	......	......
17	A	65	80	A	65	80	B	70	......	......
18	C	......	......	......	......	......	C	......	......	......
19	......	......	......	......	......	......	......	......	......	......
20	......	......	......	......	......	......	D	......	......	......
21	30	70	E	30	70	E	110	90	E	......
22	......	......	......	......	......	......	......	......	......	......
23	70	80	F	70	80	F	140	100	200	......
24	80	80	G	80	80	G	160	100	G	......
25	......	......	......	......	......	......	......	......	......	......
26	H	80	150	H	80	150	I	100	......	135
27	K	80	160	K	80	160	K	100	40	120
28	......	......	......	......	......	......	......	......	......	......
29	L	80	160	L	80	160	L	100	40	120
30	100	10	M	......	......	......	100	10	M	......
31	......	......	......	......	......	......	......	......	......	......
32	80	80	80	80	80	80	160	100	25	60
33	80	80	40	80	80	40	160	100	15	30
34	......	......	......	......	......	......	......	......	......	......
35	80	40	160	80	40	160	160	50	40	120
36	80	20	160	80	20	160	160	25	40	120
37	......	......	......	......	......	......	......	......	......	......
38	......	......	......	......	......	......	200	20	N	......
39	......	......	......	......	......	......	O	......	......	......
40	......	......	......	......	......	......	......	......	......	......

[1] Superphosphate as dissolved bone-black previous to 1897; as acid phosphate, 1897 and since. [2] Applied in April.

A. Wheat bran, 500 pounds.
B. Wheat bran, 1,000 pounds.
C. Barnyard manure, 16,000 pounds, on wheat and corn only.
D. Barnyard manure, 8,000 pounds, on wheat and corn only.
E. Linseed oil-meal, 500 pounds.
F. Dried blood, 200 pounds.
G. Sulphate of ammonia, 120 pounds.
H. Raw bone meal, 55 pounds.
I. Raw bone meal, 110 pounds.
K. Acid phosphate previous to 1897; dissolved bone-black since. phosphoric acid on Plots 11 and 27 equivalent.
L. Basic slag, 65 pounds on corn and oats, 130 pounds on wheat.
M. Tankage, 7 and 30, 100 pounds.
N. Tankage, 7 and 30, 200 pounds.
O. Barnyard manure, 32,000 pounds, on wheat only.

TABLE IV. FERTILIZERS ON CROPS GROWN IN FIVE-YEAR ROTATION.

Total quantity of fertilizing materials applied per acre during the five years of a rotation, with fertilizing constituents carried and cost of total application.

Pl't No.	Fertilizing materials					Fertilizing constituents			
	Superphosphate	Muriate of potash	Nitrate of soda	Dried blood	Total	Phosphoric acid	Potash	Nitrogen	Cost of fertilizers
	Pounds	Pounds		Pounds	Pounds	Pounds	Pounds	Pounds	
2	320	....	....	....	320	50	....	....	$2 40
3	....	260	....	....	260	....	130	....	6 50
5	....	....	440	40	480	....	....	75	12 00
6	320	....	440	40	800	50	....	75	14 40
8	320	260	....	....	580	50	130	....	8 90
9	....	260	440	40	740	....	130	75	18 50
11	320	260	440	40	1,060	50	130	75	20 90
12	320	260	680	40	1,300	50	130	112	26 90
14	240	180	280	40	740	38	90	50	14 30
15	160	100	120	40	420	25	50	25	7 70
17	A	200	120	40	....	50	130	75	19 00
18	B	....	....	....	32,000	66	170	150	8 00
20	B	....	....	....	16,000	33	85	75	4 00
21	170	230	C	....	1,900	51	135	81	....
23	320	260	....	600	1,180	50	130	75	....
24	320	260	D	....	940	50	130	74	....
26	E	260	435	....	915	50	[illegible]	77	....
27	F	260	440	40	1,080	50	[illegible]	75	....
29	G	260	440	40	1,000	50	[illegible]	75	....
30	200	20	H	....	420	50	10	12	3 75
32	320	260	60	25	820	50	130	38	14 90
33	320	260	30	15	700	50	130	19	11 90
35	320	130	120	40	930	50	65	75	17 65
36	320	65	120	40	865	50	32	75	16 03
38	200	20	H	....	420	50	10	12	3 75
39	B	....	....	....	32,000	66	170	150	8 00

A Wheat bran, 2,000 pounds, 1894-98.
B Barnyard manure from horses.
C Linseed oil-meal, 1,500 pounds.
D Sulphate of ammonia, 360 pounds.
E Bone meal, 220 pounds.
F Acid phosphate, 340 pounds, 1894-96. Dissolved bone black, 280 pounds, 1897.
G Basic slag, 260 pounds.
H Tankage, (7 and 30) 200 pounds. Superphosphate as acid phosphate.

rate of ten pounds only, and on Plots 35 and 36, at Strongsville, where the quantity is reduced to 40 and 20 pounds respectively.

On Plot 17 wheat bran is used as the carrier of all the phosphoric acid and part of the nitrogen and potash, and on Plot 21 linseed oil-meal is used as the carrier of all the nitrogen and part of the phosphoric acid and potash. On Plot 23 dried blood, and on Plot 24 sulphate of ammonia is substituted for nitrate of soda. On Plot 26 raw bone meal is used as the carrier of the phosphoric acid and part of the nitrogen, the total nitrogen being brought up, by the addition of nitrate of soda, to the quanity used on other standard plots. On Plot 27 acid phosphate has been used as the carrier of phosphoric acid previous to 1897, and dissolved bone-black since, this plot being compared with Plot 11. On Plot 29 basic slag is used as the carrier of phosphoric acid. On Plot 30 is used a mixed fertilizer, having approximately the composition of the best ready-mixed fertilizers sold in the state. For the crops of 1894 and 1895, at the Central Station, this fertilizer was mixed from dissolved bone-black, nitrate of soda and muriate of potash. In 1895 a ready-mixed fertilizer, having approximately the same analysis ("Ammonia 3 to 4 per cent., phosphoric acid 8 to 10 per cent., potash 2 to 2½ per cent.") was used at Strongsville, and in 1896 and since, the fertilizer has been mixed from tankage, acid phosphate and muriate of potash for both experiments.

In the tests herein reported the corn was grown on old sod land at Strongsville and Wooster in 1894, and on land that had grown cowpeas and clover the preceding season at Wooster in 1895 and 1896. In 1897 it followed clover and timothy at Wooster and navy beans at Strongsville.

The land at Wooster was underdrained in 1893 by tile drains laid 36 feet apart. That at Strongsville had not been drained previous to 1897, but was plowed in narrow lands, giving partial surface drainage. The season of 1895 was dry and the crop was exceptionally good for that land, but in 1896 it suffered from excess of rain. In 1897 all the land at Strongsville was drained except Section E.

In both 1895 and 1896 the wheat crop on the thin land on which this test is located at the Central Station suffered severely from winter killing, followed by spring drouth, the average yield of the unfertilized plots falling to three bushels per acre in 1895, and to one bushel in 1896. The destruction of crop was only partially prevented by fertilizers. On the heavy clay of the sub-station the wheat was so completely destroyed that no attempt was made to harvest it separately; the most heavily fertilized plots showed but little if any more wheat than the unfertilized plots at the Central Station.

There have been thus far harvested at Wooster in these experiments 5 crops of corn, 6 each of oats and wheat and 8 of hay, 4 of the first year's growth—chiefly clover, and 4 of the second year—chiefly timothy. The clover which should have made the first year's harvest for 1899 was destroyed by the severe winter, and soy beans were sown instead.

PLATE II.

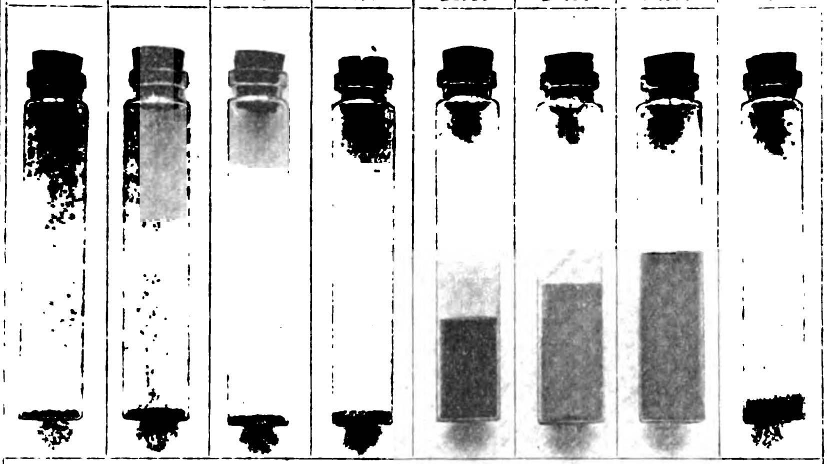
OHIO AGRICULTURAL EXPERIMENT STATION.

CHEMICAL DEPARTMENT.

Character of Soils of Station East Farm, Wooster, O.

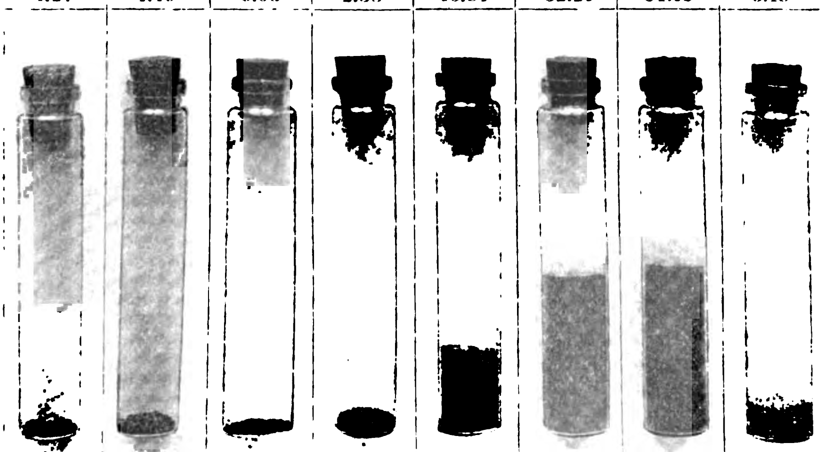
Per cent of Gravel, Sand, Silt, and Clay in 20 Grams of Soil.

Gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Fine silt.	Clay.
0.56	0.86	0.71	1.79	20.47	29.97	36.07	4.74



Per cent of Gravel, Sand, Silt, and Clay in 20 Grams of Sub-Soil.

1.27*	1.49	0.93	2.35	16.84	32.21	34.18	6.15



2.0-1.0 mm.	1.0-0.5 mm.	.5-.25 mm.	.25-.1 mm.	.1-.05 mm.	.05-.01 mm.	.01-.005 mm.	.005-.0001 mm.

DIAMETER OF SOIL PARTICLES IN MILLIMETERS.

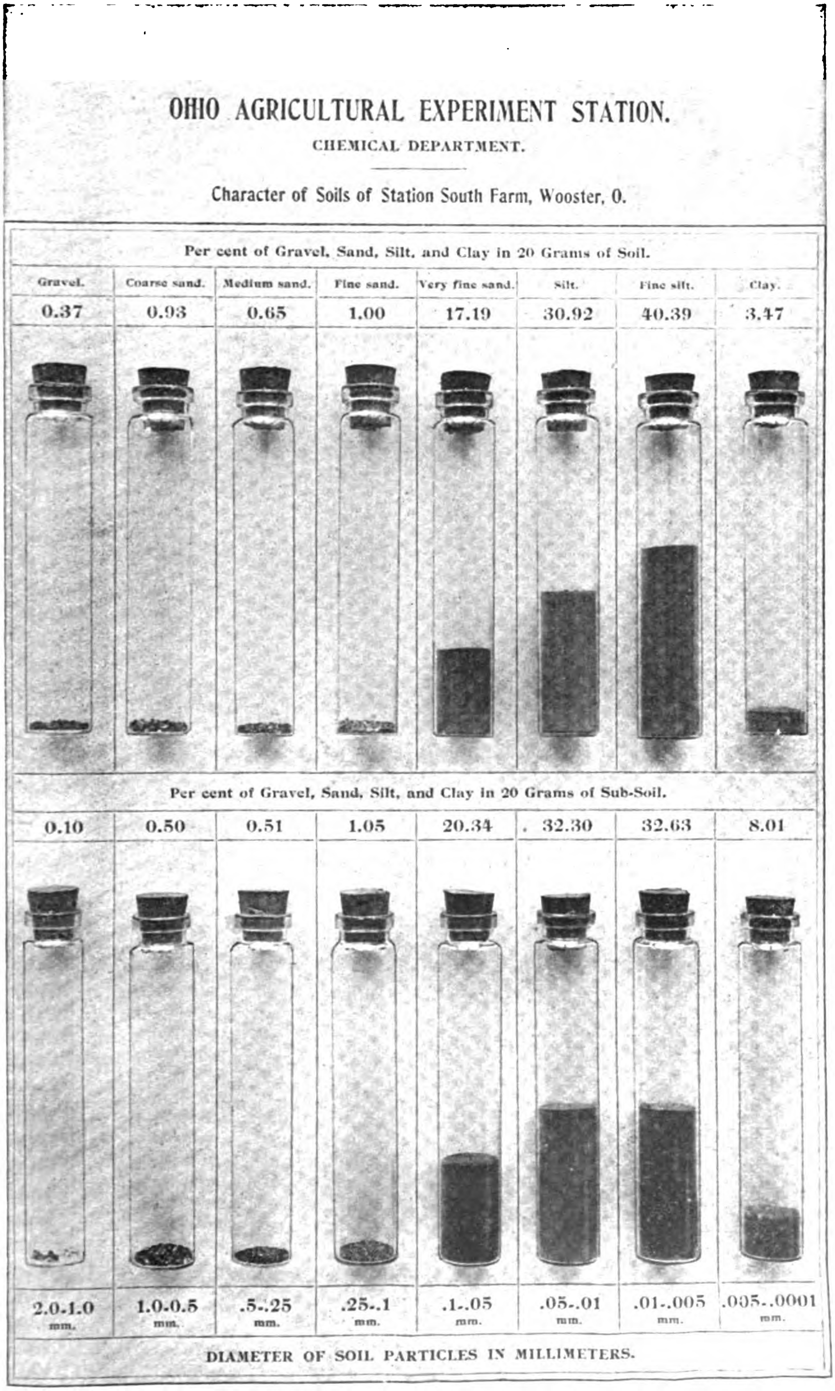
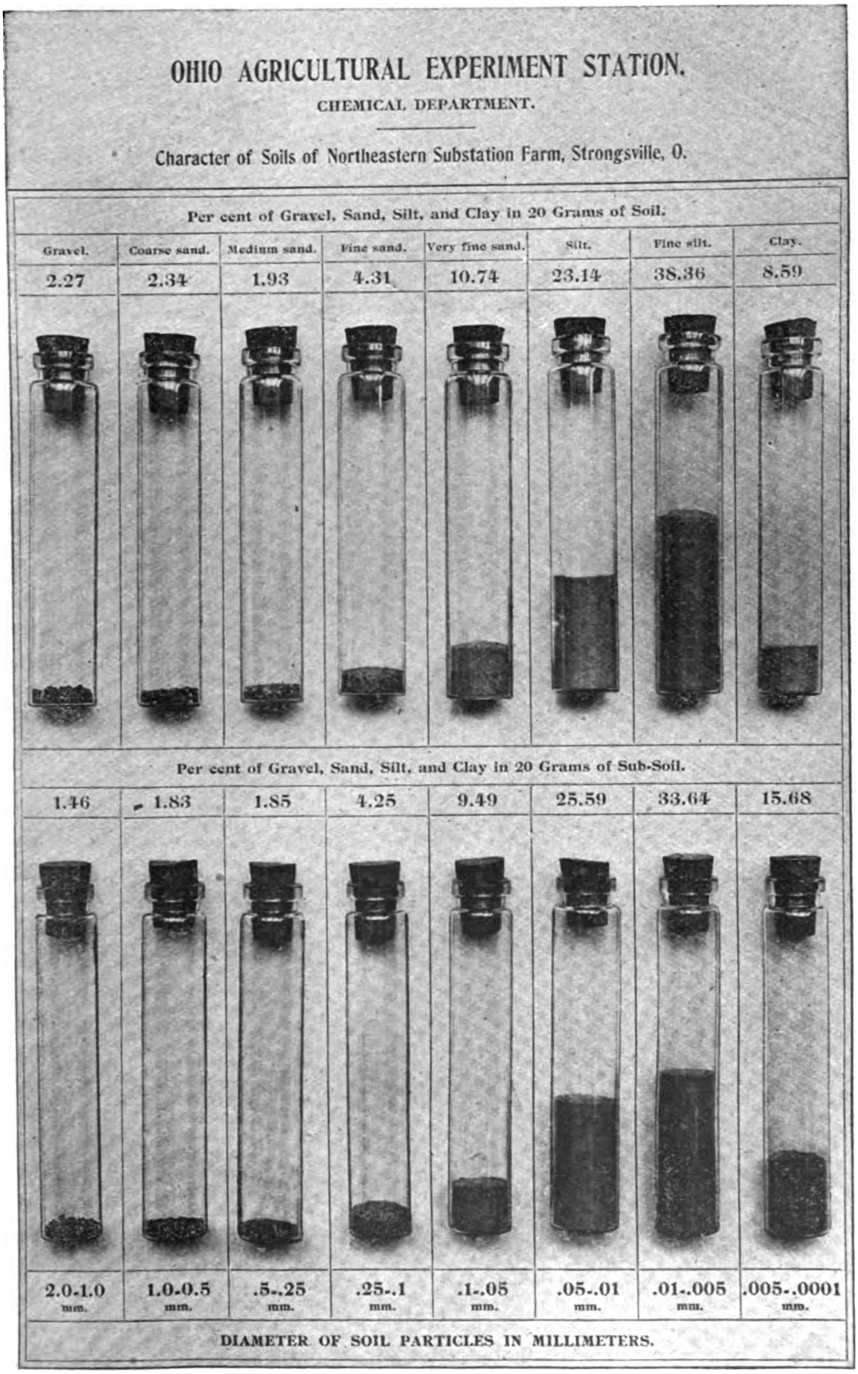

OHIO AGRICULTURAL EXPERIMENT STATION.
CHEMICAL DEPARTMENT.
Character of Soils of Station South Farm, Wooster, O.
Per cent of Gravel, Sand, Silt, and Clay in 20 Grams of Soil.
Gravel.
Coarse sand.
Medium sand.
Fine sand.
Very fine sand.
Silt.
Fine silt.
Clay.
0.37
0.93
0.65
1.00
17.19
30.92
40.39
3.47
Per cent of Gravel, Sand, Silt, and Clay in 20 Grams of Sub-Soil.
0.10
0.50
0.51
1.05
20.34
32.30
32.63
8.01
2.0-1.0 mm.
1.0-0.5 mm.
.5-.25 mm.
.25-.1 mm.
.1-.05 mm.
.05-.01 mm.
.01-.005 mm.
.005-.0001 mm.
DIAMETER OF SOIL PARTICLES IN MILLIMETERS.

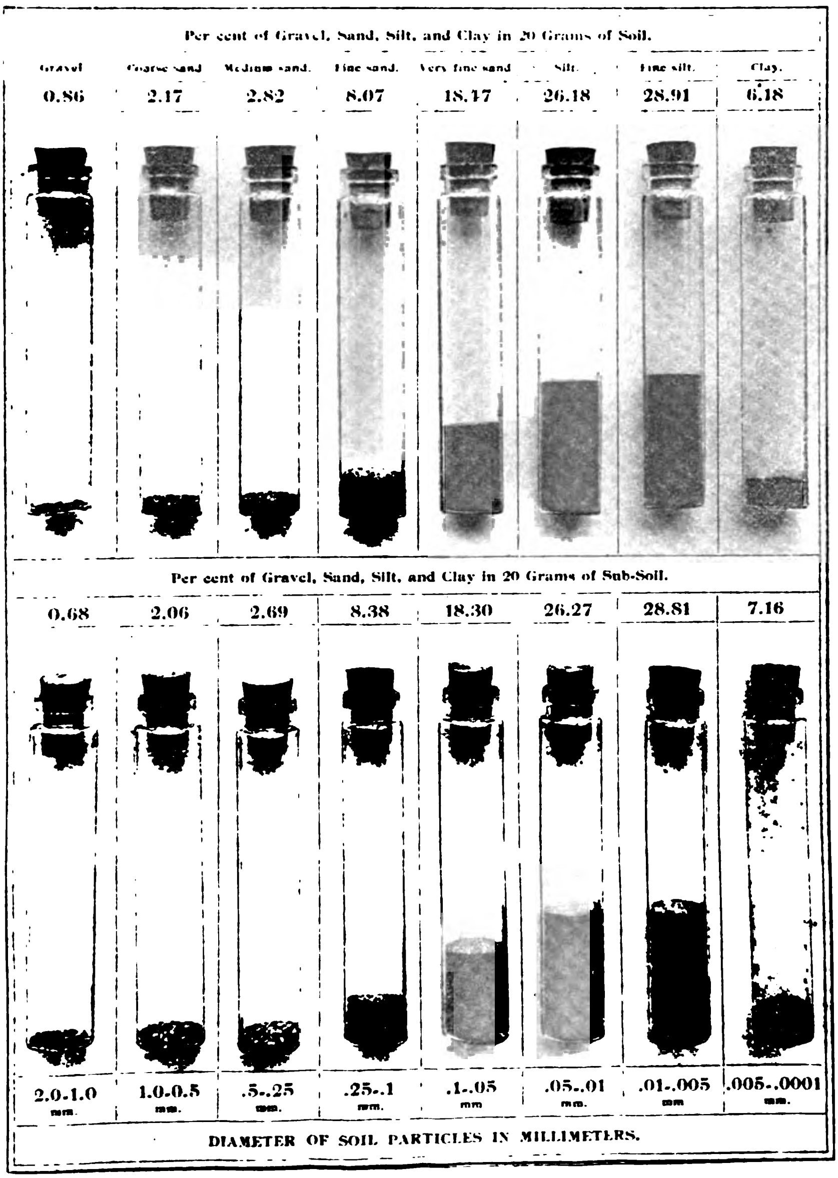
Plate IV.


OHIO AGRICULTURAL EXPERIMENT STATION.
CHEMICAL DEPARTMENT.
Character of Soils of Northeastern Substation Farm, Strongsville, O.
Per cent of Gravel, Sand, Silt, and Clay in 20 Grams of Soil.
Gravel. | Coarse sand. | Medium sand. | Fine sand. | Very fine sand. | Silt. | Fine silt. | Clay.
2.27 | 2.34 | 1.93 | 4.31 | 10.74 | 23.14 | 38.36 | 8.59
Per cent of Gravel, Sand, Silt, and Clay in 20 Grams of Sub-Soil.
1.46 | 1.83 | 1.85 | 4.25 | 9.49 | 25.59 | 33.64 | 15.68
2.0-1.0 mm. | 1.0-0.5 mm. | .5-.25 mm. | .25-.1 mm. | .1-.05 mm. | .05-.01 mm. | .01-.005 mm. | .005-.0001 mm.
DIAMETER OF SOIL PARTICLES IN MILLIMETERS.

OHIO AGRICULTURAL EXPERIMENT STATION.

CHEMICAL DEPARTMENT.

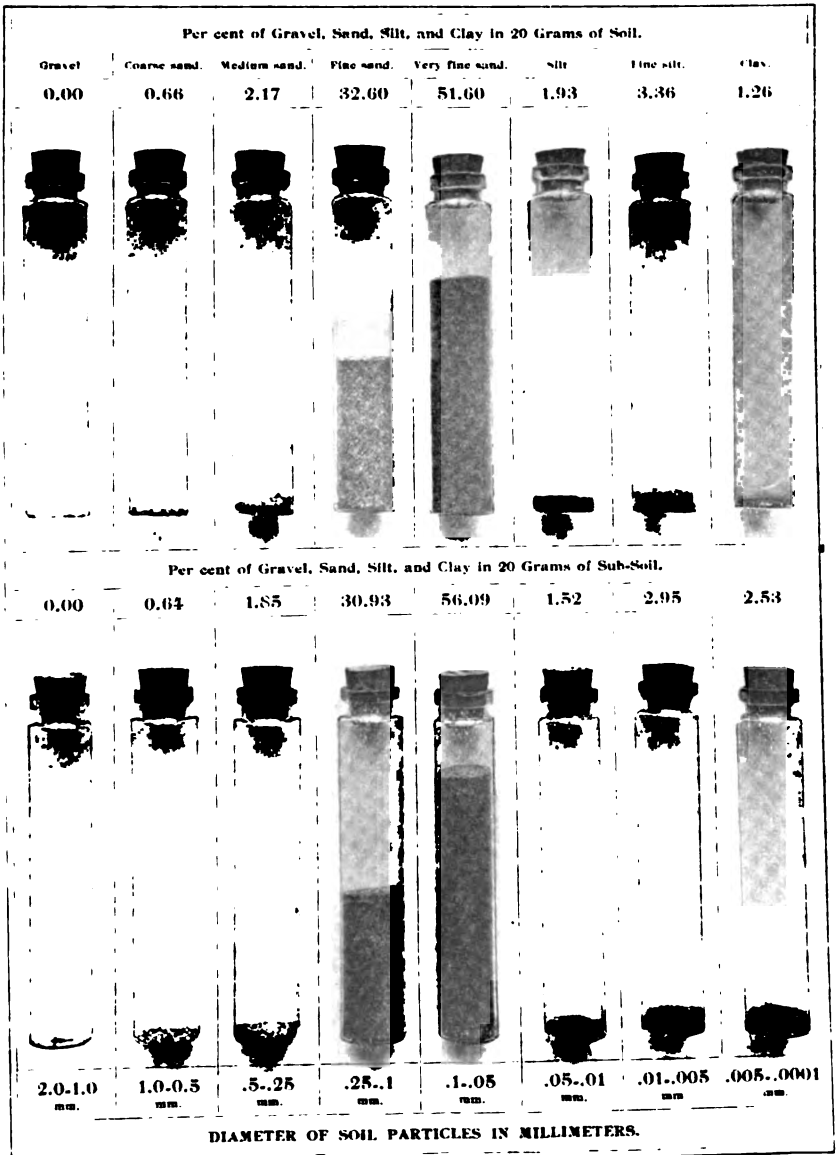
Character of Soils of North Field, Ohio State University Farm, Columbus, O.



OHIO AGRICULTURAL EXPERIMENT STATION.

CHEMICAL DEPARTMENT.

Character of Soils of Northwestern Substation Farm, Neapolis, O.



At Strongsville 4 crops of corn, 4 of oats, 3 of wheat and 3 of the first-year hay have been harvested. The first crop of wheat was completely destroyed by the severe winter of 1895-6, and the second-year hay crops have been so weedy that no safe deductions could be drawn from them.

Tables V and VI give the average annual increase from the fertilizers, as found in these tests, the statistics of actual yield being given in the Appendix.

These tables agree in giving to phosphoric acid distinctly the first place as a crop increaser on both soils, as shown by the marked increase of yield on Plot 2. In both tests the increase from potash, when used alone, is relatively small, amounting to practically nothing at Strongsville. The effect of nitrogen alone, or nitrogen with potash, is very small in both tests, but is considerably greater at Wooster than at Strongsville. A possible explanation of this difference lies in the fact that the test at Strongsville is located upon land which had lain in pasture for twenty years or more, having first been exhausted by cropping, while that at Wooster had had no such respite, having, for a like period been delivered over to the tenant farmer, under the system of annual lease which prevails in Ohio, with little or no restriction upon the tenant's liberty to despoil the land by continuous cropping without manure.

While there are as yet some minor differences in the relative effect of the various fertilizing constituents on the two soils under consideration, their differences seem to be merely variations in degree of similar effect, and therefore a consolidation of the results of the two experiments seems to be perfectly legitimate, and likely to be of wider application, as a guide to the use of fertilizers, than the results of either test taken separately. Such a consolidation is made in Diagram IV, in which an attempt is made to show the value of the increase obtained from the various fertilizers, with the proportion of the total value found in each of the crops, taking the crops at their approximate market value during recent years. In compiling this diagram ear-corn has been valued at 50 cents per cental or 35 cents per bushel; oats at 80 cents per cental, or 25.6 cents per bushel; wheat at $1.10 per cental, or 66 cents per bushel; corn stover at $3.00 per ton, oat and wheat straw at $2.00 and mixed hay at $6.00 per ton. The cost of the fertilizer is shown by the heavy black lines. At these valuations the cost of the fertilizer has been repaid in every case where phosphoric acid was used except on Plot 12; here the large application of costly nitrogen caused the cost of the fertilizer to exceed the value of the increased produce.

Of the plots receiving phosphoric acid, potash and nitrogen singly, Plot 2, receiving phosphoric acid only, shows very much the largest increase and gives a handsome profit, owing in part to the relatively low cost of the fertilizer. On Plots 3 and 5, receiving potash and nitrogen respectively, the increase is insignificant and is procured at a heavy

TABLE V: INCREASE FROM FERTILIZERS IN 5-YEAR ROTATION AT WOOSTER.

Plot	Total fertilizers applied during one rotation.	Average increase in pounds per acre.								
		Corn		Oats		Wheat		Hay		Total
		Ear-corn	Sto-ver	Grain	Straw	Grain	Straw	1st year	2d year	
2	Superphosphate,[1] 320 lbs.	277	3	210	156	216	423	461	65	1811
3	Muriate of potash, 260 lbs.	188	73	65	......	101	177	94	315	1013
5	Nitrate of soda, 440 lbs.; dried blood, 40 lbs.	163	59	114	75	97	220	104	298	1130
6	Superphosphate, 320 lbs.; nitrate,[2] 440 lbs.; blood,[3] 40 lbs.	675	217	317	367	453	906	1066	617	4618
8	Superphosphate, 320 lbs.; muriate of potash, 260 lbs.	425	285	259	322	355	511	806	324	3287
9	Muriate of potash, 260 lbs.; nitrate, 440 lbs.; blood, 40 lbs.	104	161	77	124	137	250	366	223	1442
11	Superphos., 320 lbs.; potash,[4] 260 lbs.; nitrate, 440 lbs.; blood, 40 lbs.	750	323	464	675	708	1413	1023	762	6118
12	Superphos., 320 lbs.; potash, 260 lbs.; nitrate, 680 lbs.; blood, 40 lbs.	706	293	495	785	749	1518	1172	443	6161
14	Superphos., 240 lbs.; potash, 180 lbs.; nitrate, 280 lbs.; blood, 40 lbs.	730	340	210	312	581	1254	1058	565	5050
15	Superphos., 160 lbs.; potash, 100 lbs.; nitrate, 120 lbs.; blood, 40 lbs.	*414	*138	*33	*91	533	1076	594	280	2483
17	Wheat bran, 2000 lbs.; potash, 200 lbs.; nitrate, 160 lbs.	461	165	340	485	366	725	923	360	3825
18	Barnyard manure, 16,000 lbs.	703	407	200	349	311	802	1407	1105	5284
20	Barnyard manure, 8,000 lbs.	497	300	119	212	220	539	863	760	3510
21	Superphos., 170 lbs.; potash, 230 lbs.; linseed oil-meal, 1,500 lbs.	501	292	301	505	653	1348	924	418	4942
23	Superphos., 280 lbs.; potash, 260 lbs.; dried blood, 600 lbs.	540	265	389	369	517	999	946	417	4445
24	Superphos., 320 lbs.; potash, 260 lbs.; sulphate ammonia, 360 lbs.	682	363	471	646	552	1064	792	238	4808
26	Bone meal, 220 lbs.; potash, 260 lbs.; nitrate soda, 435 lbs.	435	314	388	368	528	1109	953	636	4731
27	Acid phosphate, 320 lbs.; potash, 260 lbs.; nitrate, 480 lbs.; blood, 40 lbs.	440	214	430	544	589	1125	667	467	4546
29	Slag phosphate, 260 lbs.; potash, 260 lbs.; nitrate, 480 lbs.; blood, 40 lbs.	573	332	365	490	566	1150	845	950	5271
30	Superphos., 200 lbs.; potash, 20 lbs.; 7 and 30 tankage, 200 lbs.	421	124	164	192	323	627	780	890	3521

1 Superphosphate from dissolved bone black previous to spring of 1897, from acid phosphate since.
2 "Nitrate" = nitrate of soda in all cases.
3 "Blood" = dried blood " "
4 "Potash" = muriate of potash " "
5 Dissolved bone black, 1897 and since.
* Two years

TABLE VI. INCREASE (OR DECREASE—) FROM FERTILIZERS IN 5-YEAR ROTATION AT STRONGSVILLE

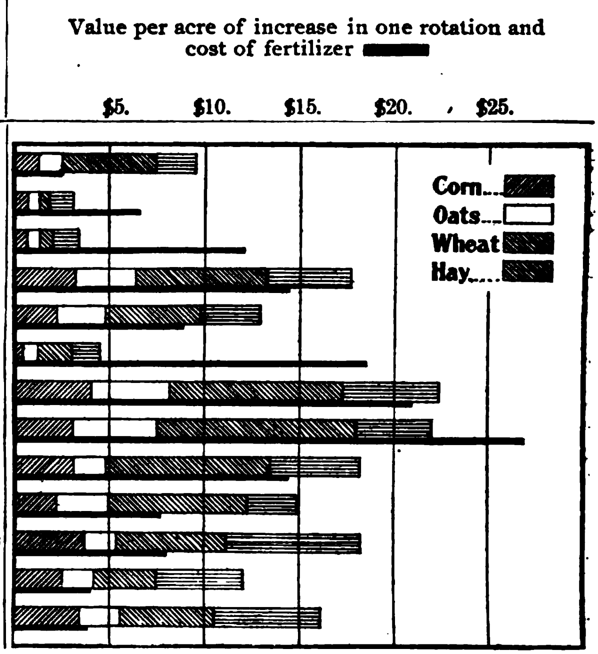
Plot	Total fertilizers applied during one rotation.	Average increase in pounds per acre							
		Corn		Oats		Wheat		Hay	Total
		Ear corn	Sto-ver.	Grain	Straw	Grain	Straw	1st y'r	
2	Superphosphate,[1] 320 lbs.	217	-12	308	315	450	990	911	3179
3	Muriate of potash, 260 lbs.	48	-23	61	57	-38	-111	72	66
5	Nitrate of soda, 440 lbs.; dried blood, 40 lbs.	70	5	6	117	-23	-52	238	361
6	Superphosphate, 320 lbs.; nitrate,[2] 440 lbs.; blood,[3] 40 lbs.	470	21	425	490	673	1208	626	4113
8	Superphosphate, 320 lbs.; muriate of potash, 260 lbs.	262	-175	333	415	473	769	676	2753
9	Muriate of potash, 260 lbs.; nitrate of soda, 440 lbs.; blood, 40 lbs.	30	-68	57	191	139	285	238	872
11	Superphos., 320 lbs.; potash,[4] 260 lbs.; nitrate, 440 lbs.; blood, 40 lbs.	684	220	389	562	739	1141	800	4535
12	Superphos., 320 lbs.; potash, 260 lbs.; nitrate, 680 lbs.; blood, 40 lbs.	522	225	422	579	997	1850	560	5155
14	Superphos., 240 lbs.; potash, 180 lbs.; nitrate, 280 lbs.; blood, 40 lbs.	288	175	147	152	826	1409	950	3947
15	Superphos., 160 lbs.; potash, 100 lbs.; nitrate, 120 lbs.; blood, 40 lbs.	......	......	......	......	666	1096	594	......
17	Wheat bran, 2000 lbs.; potash, 200 lbs.; nitrate, 160 lbs.	200	12	351	584	354	598	748	2847
18	Barnyard manure, 16,000 lbs.	588	136	187	238	710	1268	1006	4133
20	Barnyard manure, 8,000 lbs.	393	61	100	168	430	720	629	2501
21	Superphos., 170 lbs.; potash, 230 lbs.; linseed oil-meal, 1,500 lbs.	255	96	338	622	537	968	708	3524
23	Superphos., 280 lbs.; potash, 260 lbs.; dried blood, 600 lbs.	402	-22	415	782	611	1108	1073	4369
24	Superphos., 320 lbs.; potash, 260 lbs.; sulphate ammonia, 360 lbs.	399	112	437	693	662	1208	884	4395
26	Bone meal, 220 lbs.; potash, 260 lbs.; nitrate soda, 435 lbs.	309	203	451	471	770	1304	1039	4547
27	Acid phosphate,[5] 320 lbs.; potash, 260 lbs.; nitrate, 440 lbs.; blood, 40 lbs.	464	227	436	627	574	933	591	3852
29	Slag phosphate, 260 lbs.; potash, 260 lbs.; nitrate, 440 lbs.; blood, 40 lbs.	626	148	448	584	878	1473	973	5130
30	Superphos., 200 lbs.; potash, 20 lbs.; 7 and 30 tankage, 200 lbs.	847	165	369	414	672	1157	1173	4797
32	Superphos., 320 lbs.; potash, 260 lbs.; nitrate, 220 lbs.; blood, 25 lbs.	512	84	408	502	684	1140	1032	4362
33	Superphos., 320 lbs.; potash, 260 lbs.; nitrate, 110 lbs.; blood, 15 lbs.	522	28	386	598	511	628	1251	3924
35	Superphos., 320 lbs.; potash, 130 lbs.; nitrate, 440 lbs.; blood, 40 lbs.	361	110	425	621	685	1117	878	4197
36	Superphos., 320 lbs.; potash, 65 lbs.; nitrate, 440 lbs.; blood, 40 lbs.	650	338	413	496	731	1294	1079	5001
38	Superphos., 200 lbs.; potash, 20 lbs.; 7 and 30 tankage, 200 lbs.	......	......	......	......	603	1111	1057	......
39	Barnyard manure, 32,000 lbs., on wheat only	......	......	......	......	344	550	663	......

1 Superphosphate from dissolved bone black previous to spring of 1897, from acid phosphate since.
2 "Nitrate"—nitrate of soda in all cases.
3 "Blood"—dried blood in all cases.
4 "Potash"—muriate of potash in all cases.
5 Dissolved bone black, 1897 and since.
* Two years.

DIAGRAM IV.—FERTILIZERS APPLIED PER ACRE ON CROPS GROWN IN FIVE-YEAR ROTATION AND VALUE OF INCREASE PER ACRE.

Average of nine rotations.

Plot No.	Total fertilizers applied in five years		
	Super-phos-phate	Muriate of potash	Nitrate of soda*
	Pounds	*Pounds*	*Pounds*
2	320	...	...
3	...	260	...
5	...	..	480
6	320	...	480
8	320	260	...
9	...	260	480
11	320	260	480
12	320	260	720
14	240	180	320
15	160	100	160
18	Barnyard manure, 16 tons		
20	Barnyard manure, 8 tons		
30	Acid phosphate, 200 lbs.; 7-30 tankage.... 200 lbs.; Muri'te of potash 20 lbs.		



*Nitrate of soda and dried blood.

financial loss, which becomes still greater on Plot 9, receiving these two constituents in combination, but no phosphoric acid.

Plot 6 shows an increase nearly double that found on Plot 2, and much greater than the combined increase from Plots 2 and 5, but the margin of profit is narrowed because of the high cost of the nitrogen. The increase on Plot 8 is practically equal to the combined increase of Plots 2 and 3, but here again the profit is reduced because of the comparatively high cost of the potash.

The increase of Plot 11, receiving the complete fertilizer, is much greater than the combined increase from the same quantities of fertilizing materials used separately, but the profit is almost obliterated by the cost of the fertilizers.

On Plots 14 and 15 the attempt is made to extend the effect of the fertilizers by increasing the time between applications, thus giving greater opportunity to secure the full residual effect. The result is a diminished total increase, but an increasing margin of profit, until on Plot 15, fertilized only once in five years, on the wheat crop, we have a total increase amounting in average value to nearly $15.00 per acre, produced

at a cost of but little more than half that amount, by a complete fertilizer, carrying all three of the leading constituents; the net profit being the same as that found on Plot 2.

Passing the two manured plots, we find on Plot 30 the largest net profit shown by any plot in the series. This plot receives practically the same quantity of available phosphoric acid as that given to Plot 2, and in addition a small quantity each of nitrogen and potash, the nitrogen being conveyed in the comparatively cheap carrier of slaughter-house tankage. The total application to this plot is 420 pounds in the five years, divided between the corn and wheat crops, carrying 50 pounds of phosphoric acid, 10 pounds of potash and 12 pounds of nitrogen, and costing $3.75. Plot 15 receives, during the same period, an application of the same quantity of fertilizer, carrying 25 pounds each of phosphoric acid and nitrogen and 50 pounds of potash, and costing $7.75. It is evident that, in the present condition of the soils under test, it is more profitable to use more phosphoric acid and less potash, and probably also less nitrogen than is being given to Plot 15; and yet, even when clover forms a regular part of the rotation, it is profitable to add some nitrogen to the fertilizer. This last point is again illustrated by comparing Plots 8 and 15. Plot 8 receives two and one-half times as much potash as Plot 15; it also receives twice as much phosphoric acid, which all this work shows to be the dominant constituent of fertility on the soils under test, but it gets no nitrogen except that furnished by the clover. The total cost of its fertilizing is considerably greater than that of Plot 15, yet its total increase is decidedly smaller.

This point is again brought out by comparing Plots 6 and 8. The substitution of the nitrogen of Plot 6 for the potash of Plot 8 produces a marked increase of yield, yet the large gain of Plot 11 over Plot 6 shows that potash cannot be entirely dispensed with if the highest yield is to be obtained.

It appears to be clear, therefore, that under the conditions of this experiment, which is made on soils of reduced fertility, and on which there has been no systematic culture of leguminous crops, previous to the beginning of this test, we are not maintaining in the soil a supply of nitrogen sufficient for maximum crop production by simply growing one crop of clover in five years, the roots of which only are left in the soil, the tops being made into hay and removed from the land.

It also appears to be equally clear that, while the present demand for potash, by the soils under consideration, is less urgent than that for phosphoric acid and nitrogen, yet the aid of potash cannot be entirely dispensed with if the largest production is to be attained.

In the lines showing the effect of barnyard manure—Plots 18 and 20—the cost of the manure is estimated at 50 cents per ton, a sum much more than sufficient to cover the wages of man and team for the time required to move it from the barnyard to the field and spread it there, on

the ordinary farm.* If the manure is to be bought and then hauled several miles its cost may easily exceed that of a dressing of commercial fertilizers producing an equivalent effect.

In comparing the effect of the barn-yard manure with that of the commercial or chemical fertilizers, it will be seen that while the latter produce a relatively greater increase in the grain crops, the grass crops show greater benefit from the manure.

The diagram shows that the larger total increase and the greater net profit have come from the larger application of manure, but the larger profit per ton of manure has come from the smaller application; the 16 tons of manure on Plot 18 having produced an increase worth $18.00, or $1.12 per ton; whereas the 8 tons applied to Plot 20 has produced increase worth $12.00, or $1.50 per ton.† These estimates, it will be observed, are based upon very low prices of produce.

FERTILIZERS ON POTATOES AND WHEAT GROWN IN ROTATION WITH CLOVER.

An experiment in the culture of potatoes, wheat and clover in a three-year rotation is in progress at the Central Station at Wooster, and at the sub-stations at Strongsville and Neapolis, having been commenced at Wooster and Neapolis in 1894 and at Strongsville in 1895. At the Central Station at Wooster the test is located on the "South Farm," the soil of which does not differ materially in mechanical texture or chemical composition from that of the adjoining "East Farm," on which the 5-year rotation, previously considered, is located, but this farm had not been subjected to such exhaustive cropping, previous to the beginning of the test, as had the East Farm, and it was therefore in a much better condition of fertility.

The general plan of this experiment, shown in Table VII, is essentially the same as that of the 5-year rotation, the only important difference being that in the potato rotation the total application of fertilizers is considerably increased on Plots 14 and 15, instead of being decreased, as in the cereal rotation.

At the Central Station 6 crops of potatoes, 5 of wheat and 4 of clover have been harvested in this experiment, and 4 of potatoes and three of wheat at the Strongsville sub-station. One crop each of potatoes and wheat has been lost at the sub-station because of unfavorable weather

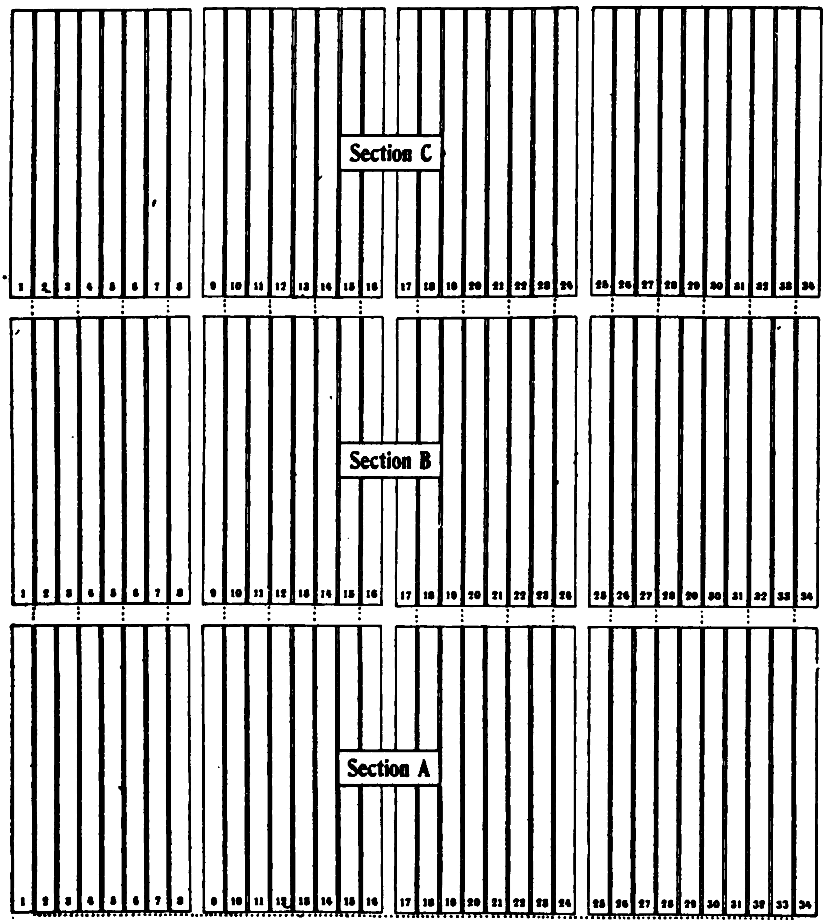
*At this Station 12 acres of land is annually top-dressed with barnyard manure, the manure being applied with a manure spreader, at the rate of 9 tons per acre, after the land has been plowed for wheat. Our books show that one man with a team has taken 108 tons of manure from the barnyard and distributed it uniformly over the field in 9 days time, or 12 tons per day. At $3.00 per day for man and team the cost of this application would be 25 cents per ton, or $2.25 per acre.

† On the assumption that the increase in the second-year hay crops at Strongsville will bear the same proportion to the first-year crops as that found at Wooster.

DIAGRAM V. ARRANGEMENT OF PLOTS IN 3-YEAR ROTATION OF POTATOES, WHEAT AND CLOVER, SOUTH FARM, CENTRAL STATION.

Plots one-tenth acre.

North.



conditions, and the hay crops there have thus far been plowed under in order to bring the land into better physical condition. The increase from the fertilizers in this experiment is given in Tables VIII and IX. From these tables it will be observed that the increase at Strongsville is generally larger than that at Wooster, but the variations, due to differences in fertilizing, follow the same general course, indicating that the general needs of the two soils are similar.

In Diagram VII the results of the two tests are consolidated, and the value of the increase is calculated as in Diagram IV, potatoes being

DIAGRAM VI. ARRANGEMENT OF PLOTS IN 3-YEAR ROTATION OF POTATOES, WHEAT AND CLOVER AT NORTHEASTERN SUBSTATION.

Plots one-twentieth acre.

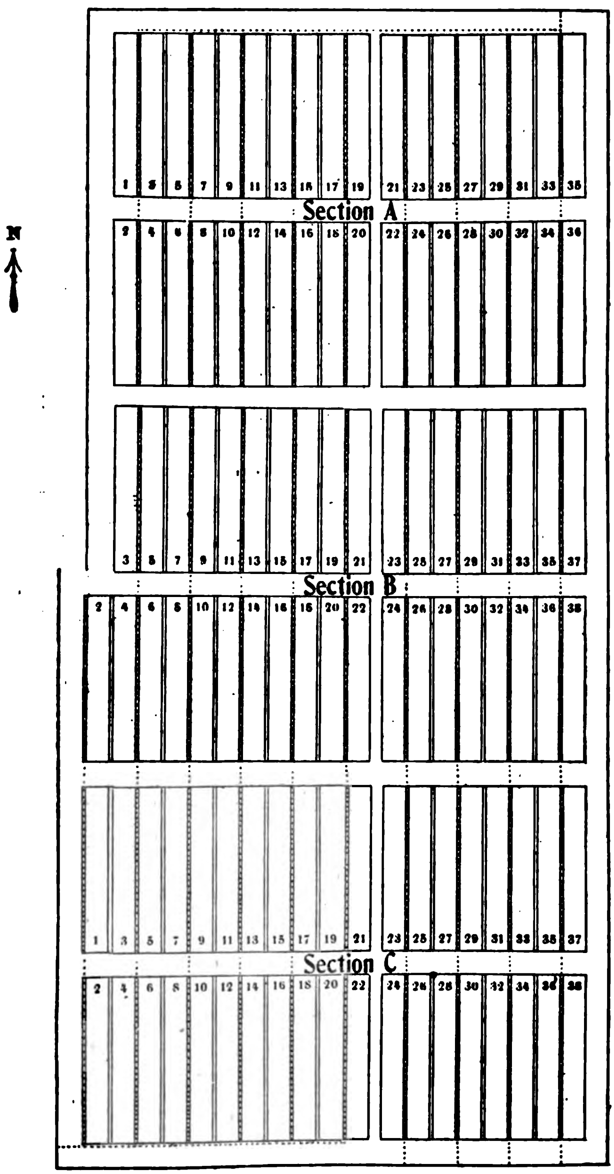


TABLE VII. PLAN OF FERTILIZING IN 3-YEAR ROTATION.

Fertilizers in pounds per acre.

Plot	Fertilizing materials per acre								Total fertilizing constituents per acre			Cost of fer-tiliz'rs per acre
	On Potatoes			On Wheat				Total fertil-izers in 3 years				
	Super phos-phate	Muri-ate of pot-ash	Nit-rate of soda	Super phos-phate	Muri-ate of pot-ash	Dri-ed bl'd	Nit-rate of soda		Phos-phor'c acid	Pot-ash	Nitro-gen	
1	......	......	......	......	......	....	......	......	......	......	......	......
2	160	......	......	160	......	....	......	320	50	......	......	$2 40
3	......	100	......	......	100	....	......	200	......	100	......	5 00
4	......	......	......	......	......	....	......	......	......	......	......	......
5	......	......	80	......	......	40	120	240	......	......	38	6 00
6	160	......	80	160	......	40	120	560	50	......	38	8 40
7	......	......	......	......	......	....	......	......	......	......	......	......
8	160	100	......	160	100	....	......	520	50	100	......	7 40
9	......	100	80	......	100	40	120	440	......	100	38	11 00
10	......	......	......	......	......	....	......	......	......	......	......	......
11	160	100	80	160	100	40	120	760	50	100	38	13 40
12	160	100	160	160	100	40	200	920	50	100	62	17 30
13	......	......	......	......	......	....	......	......	......	......	......	......
14	320	200	160	160	100	40	120	1,100	75	150	50	19 10
15	480	300	320	......	......	....	......	1,100	75	150	50	19 10
16	......	......	......	......	......	....	......	......	......	......	......	......
17	......	......	......	A	......	....	......	......	......	......	......	2 00
18	......	......	......	B	......	....	......	......	......	......	......	4 00
19	......	......	......	......	......	....	......	......	......	......	......	......
20	80	85	C	D	70	....	......	1,735	50	100	38	......
21	120	95	E	110	90	....	F	1,165	50	100	38	......
22	......	......	......	......	......	....	......	......	......	......	......	......
23	150	100	G	140	100	....	H	790	50	100	38	......
24	160	100	I	160	100	....	K	700	50	100	38	......
25	......	......	......	......	......	....	......	......	......	......	......	......
26	L	100	55	L	100	....	135	610	50	100	38	......
27	M	100	80	M	100	40	120	760	50	100	38	......
28	......	......	......	......	......	....	......	......	......	......	......	......
29	N	100	80	N	100	40	120	700	50	100	38	......
30	B	......	......	......	......	....	......	......	......	......	......	......
31	......	......	......	......	......	....	......	......	......	......	......	......
32	......	......	......	O	......	....	......	......	......	......	......	......
33	P	......	......	P	......	....	......	420	50	10	12	3 75
34	......	......	......	......	......	....	......	......	......	......	......	......
35	160	50	80	160	50	40	120	580	50	50	38	10 90
36	160	25	80	160	25	40	120	530	50	25	38	9 65
37	......	......	......	......	......	....	......	......	......	......	......	......
38	......	......	......	......	......	....	......	......	......	......	......	......

Explanation: Superphosphate as dissolved bone black previous to 1897; as acid phosphate beginning with the spring of 1897.

A. Barnyard manure, 4 tons.
B. Barnyard manure, 8 tons.
C. Wheat bran, 500 pounds.
D. Wheat bran, 1,000 pounds.
E. Linseed oil meal, 250 pounds.
F. Linseed oil meal, 500 pounds.
G. Dried blood, 100 pounds.
H. Dried blood, 200 pounds.
I. Sulphate ammonia, 60 pounds.
K. Sulphate ammonia, 120 pounds.
Plots 35 to 38 at Strongsville only.

L. Bone meal, 110 pounds.
M. Acid phosphate, 170 pounds, 1894-96, dissolved bone black, 140 pounds, 1897 and 1898, 160 pounds, 1899.
N. Basic slag, 130 pounds.
O. Barnyard manure, 16 tons, beginning fall of 1896.
P. Acid phosphate, 100 pounds, tankage, 100 pounds, muriate of potash, 10 pounds, beginning 1896.

TABLE VIII. INCREASE FROM FERTILIZERS IN 3-YEAR ROTATION OF POTATOES, WHEAT AND CLOVER AT CENTRAL STATION, WOOSTER.

Plot	Total fertilizers applied during one rotation, in pounds per acre	Average increase in pounds per acre			
		Potatoes, 6 crops	Wheat, 5 crops		Hay, 4 crops
			Grain	Straw	
2	Superphosphate, 320	1116	224	334	161
3	Muriate of potash, 200	526	129	28	—61
5	Nitrate of soda, 200; dried blood, 40	405	138	370	198
6	Superphosphate, 320; nitrate of soda, 200; dried blood, 40	1792	455	748	398
8	Superphosphate, 320; muriate of potash, 200	1537	446	509	222
9	Muriate of potash, 200; nitrate of soda, 200; dried blood, 40	977	394	457	402
11	Superphosphate, 320; muriate of potash, 200; nitrate of soda, 200; dried blood, 40	1214	524	779	132
12	Superphosphate, 320; muriate of potash, 200; nitrate of soda, 360; dried blood, 40	1772	599	995	478
14	Superphosphate, 480; muriate of potash, 300; nitrate of soda, 280; dried blood, 40	22[illegible]2 ~~967~~	661	1017	440
15	Superphosphate, 480; muriate of potash, 300; nitrate of soda, 280; dried blood, 40	2406	553	762	550
17	Barnyard manure, 4 tons, on wheat only	605	173	280	485
18	Barnyard manure, 8 tons, on wheat only	811	262	395	949
20	Superphosphate, 80; muriate of potash, 155; wheat bran, 1,500	2027	308	482	745
21	Superphosphate, 230; muriate of potash, 185; linseed oil-meal, 750	1615	506	702	405
23	Superphosphate, 290; muriate of potash, 200; dried blood, 300	1899	529	834	75
24	Superphosphate, 320; muriate of potash, 200; sulphate of ammonia, 180	1558	539	809	167
26	Raw bone meal, 220; muriate of potash, 200; nitrate of soda, 190	816 ~~1063~~	592	1033	208
27	Acid phosphate, 320; muriate of potash, 200; nitrate of soda, 200; dried blood, 40	1313	597	932	192
29	Slag phosphate, 260; muriate of potash, 200; nitrate of soda, 200; dried blood, 40	1159	641	1059	915
30	Barnyard manure, 8 tons, on potatoes only	2186	252	315	706
32	Barnyard manure, 16 tons, on wheat only	[2]1510	513	811	926
33	Acid phosphate, 200; muriate of potash, 20; 7 and 30 tankage, 200	[3]578	595	911	328

[1] 5 crops. [2] 2 crops. [3] 4 crops.

TABLE IX. INCREASE FROM FERTILIZERS IN 3-YEAR ROTATION OF POTATOES, WHEAT AND CLOVER AT NORTHEASTERN SUBSTATION, STRONGSVILLE.

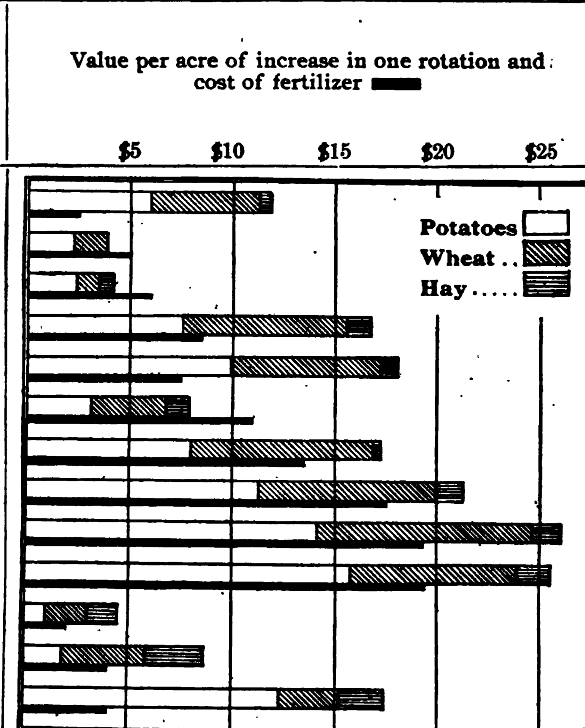
Plot	Total fertilizers applied during one rotation, in pounds per acre.	Average increase in pounds per acre		
		Potatoes, 4 crops	Wheat, 3 crops	
			Grain	Straw
2	Superphosphate, 320	1251	662	1254
3	Muriate of potash, 200	152	177	232
5	Nitrate of soda, 200; dried blood, 40	422	19	139
6	Superphosphate, 320; nitrate of soda, 200; dried blood, 40	[1]901	944	1430
8	Superphosphate, 320; muriate of potash, 200	1805	888	1280
9	Muriate of potash, 200; nitrate of soda, 200; dried blood, 40	[1]87	122	198
11	Superphosphate, 320; muriate of potash, 200; nitrate of soda, 200; dried blood, 40	1532	1003	1573
12	Superphosphate, 320; muriate of potash, 200; nitrate of soda, 360; dried blood, 40	2051	1041	1665
14	Superphosphate, 480; muriate of potash, 300; nitrate of soda, 280; dried blood, 40	2608	1137	1747
15	Superphosphate, 480; muriate of potash, 300; nitrate of soda, 280; dried blood 40	2941	821	1230
17	Barnyard manure, 4 tons, on wheat only	[2]*101	188	128
18	Barnyard manure, 8 tons, on wheat only	[2]424	502	728
20	Superphosphate, 80; muriate of potash, 155; wheat bran, 1,500	1241	271	281
21	Superphosphate, 230; muriate of potash, 185; linseed oil-meal, 750	1778	868	1156
23	Superphosphate, 290; muriate of potash 200; dried blood, 300	1338	813	1136
24	Superphosphate, 320; muriate of potash, 200; sulphate of ammonia, 180	1379	718	1164
26	Raw bone meal, 220; muriate of potash, 200; nitrate of soda, 190	1367	1052	1629
27	Acid phosphate, 320; muriate of potash, 200; nitrate of soda, 200; dried blood, 40	1996	774	1193
29	Slag phosphate, 260; muriate of potash, 200; nitrate of soda, 200; dried blood, 40	1972	1097	1611
30	Barnyard manure, 8 tons, on potatoes only	1898	185	393
32	Barnyard manure, 16 tons, on wheat only	359	916	1291

[1]3 crops. [2]2 crops. *Decrease.

DIAGRAM VII. FERTILIZERS APPLIED PER ACRE ON CROPS GROWN IN 3-YEAR ROTATION AND VALUE OF INCREASE PER ACRE.

Average of 8 rotations.

Plot No.	Fertilizers applied in three years: Superphosphate	Muriate of Potash	Nitrate of Soda*
	Pounds	*Pounds*	*Pounds*
2	320	...	...
3	...	200	...
5	...	...	240
6	320	...	240
8	320	200	...
9	...	200	240
11	320	200	240
12	320	200	400
14	480	300	320
15	480	300	320
17	Barnyard manure, 4 tons, on wheat		
18	Barnyard manure, 8 tons on wheat		
30	Barnyard manure, 8 tons, on potatoes		



*Nitrate of soda and dried blood.

valued at 60 cents per cental, or 36 cents per bushel, and wheat, straw and hay at the prices previously given.

Following the lines of this diagram we see that the potato and wheat crops have both been largely increased by the fertilizers, and that in this test, as in the cereal rotation, phosphoric acid has been the dominant factor in producing this increase. It will be observed that usually more than half the total increase is found in the potato crop, even at the low price at which the potatoes are valued; that there has been a profit in the use of fertilizers wherever phosphoric acid was a constituent of the fertilizer, and a loss wherever phosphoric acid was omitted.

The lines showing the larger applications of fertilizers indicate a larger total, but a smaller relative profit than when the fertilizers are used in smaller quantity; but if potatoes were valued at a higher price it would alter these proportions in favor of the more liberal use of fertilizers. We have found, in fact, that when potatoes are worth $1.00 per cental, or 60 cents per bushel, a not unusual price, the net profit on Plots 14 and 15 exceeds that on any other plot in the series, except that on Plot 8.

In the case of the potato crop the increase is less regular than that of the wheat crop in this rotation, or of the cereal crops in the longer rotation previously considered. The tables show that there has been a marked increase in the yield of potatoes wherever phosphoric acid has been applied in the fertilizer, and an insignificant increase where this constituent was omitted. The increase on Plot 2, receiving superphosphate only, compared with Plots 6, 8 and 11, on which the superphosphate has been re-enforced with nitrogen or potash, one or both, indicates that potash has produced a small increase in yield over that given by phosphoric acid alone, but leaves us in doubt whether there has been anything gained, in the soils under test, by adding nitrogen to a fertilizer for potatoes grown on a clover sod. At the Central Station the clover crops in this experiment have made good yields, with very small and irregular increase from the fertilizers. Only the first crop has been weighed each year. When the seed crop has been saved it has not been harvested separately. The clover crops at the Sub-station have been smaller, sometimes quite weedy, and, as previously stated, they have thus far been plowed under.

In the case of the wheat following the potatoes, the tables show that phosphoric acid has been an important factor in producing increase in yield, yet both potash and nitrogen have added materially to this increase, as shown below:

TABLE X. INCREASE OF WHEAT FOLLOWING POTATOES

Plot	Fertilizers	Increase, in pounds per acre			
		Wooster		Strongsville	
		Grain	Straw	Grain	Straw
2	Phosphoric acid alone	224	334	662	1254
8	Phosphoric acid and potash	446	509	888	1280
6	Phosphoric acid and nitrogen	455	748	944	1430
11	Phosphoric acid, potash and nitrogen	524	779	1003	1573
12	Phosphoric acid, potash and more nitrogen	599	995	1041	1665

Apparently, the surplus nitrogen accumulated in the soil by the clover crop is chiefly consumed by the potato crop following.

It will be observed that in this experiment Plots 14 and 15 receive the same total quantity of each of the fertilizing constituents, but on Plot 14 the dressing is divided between the potatoes and the wheat, while on Plot 15 it is all given to the wheat. The relative effect of the two modes of application is well brought out by the diagram.

FERTILIZERS ON CROPS GROWN IN CONTINUOUS CULTURE.

Experiments in the use of fertilizers and manures on wheat grown continuously on the same land were begun on the farm belonging to the Ohio State University, at Columbus, Franklin county, soon after the first organization of the Station, but the land then available proved to be unsuited to the work, and on the reorganization of the Station, under the Hatch act, a new location on the same farm was selected and prepared for the work by thorough underdraining. At the same time the scope of the test was extended to include corn and oats as well as wheat. The test was conducted under the immediate superintendence of the Agriculturist of the Station until the removal of the Station to Wooster, in 1892, since which time it has been carried on through coöperation between the Station and the Farm Department of the University, of which Prof. Thos. F. Hunt, Dean of the College of Agriculture, has been in charge.

The soil devoted to this test is of combined glacial and fluvial origin. The land lies on the east bank of the Olentangy river, at an elevation of about 20 feet above the present flood plain. The portion nearest the river lies upon a bed of gravel, which is found at a depth of two to five feet, and which gives a pervious subsoil; this portion is occupied by the corn and oats; the wheat, however, grows upon a soil 12 to 18 inches in depth, overlying a thick sheet of bowlder clay, almost impervious to water. The original forest growth was chiefly Beech and Elm on this portion, while Black Walnut (*Juglans nigra* L.) was found on the portion nearer the river. The subsoil in this test has been explored by a line of wells, four or five feet deep, dug along the east and west roadway separating the sections. Between the corn and oats these wells ended in dry gravel, but along the wheat they terminated in bowlder clay and immediately filled with water to the level of the tile drains. The line of division apparently lies under the first plots of the wheat.

The mechanical and chemical analyses, given on pp. 6 and 7, are of the soil of that portion of the tract on which wheat is grown, and show a soil rich in the mineral elements of fertility. Under-drainage, however, was essential to successful agriculture on this part of the tract, while it was needed on the remainder to equalize the moisture conditions, the gravel being in some places too far from the surface to give sufficient natural drainage.

Table XI gives the plan of fertilizing followed in this experiment, each crop receiving the same treatment, except that in the case of wheat one-fourth of the total nitrogen has been given as dried blood, applied in the fall with the seed, and three-fourths as nitrate of soda, sown broadcast in April, except on Plot 15, the sulphate of ammonia being all given in the fall.

Simultaneously with the beginning of this experiment, in 1888, the Agriculturist of the Station, Mr. J. F. Hickman, began an experiment in the continuous culture of corn on his farm near East Liverpool, Colum-

DIAGRAM VIII. ARRANGEMENT OF PLOTS IN EXPERIMENTS IN CONTINUOUS CULTURE AT COLUMBUS.

Plots one-tenth acre.

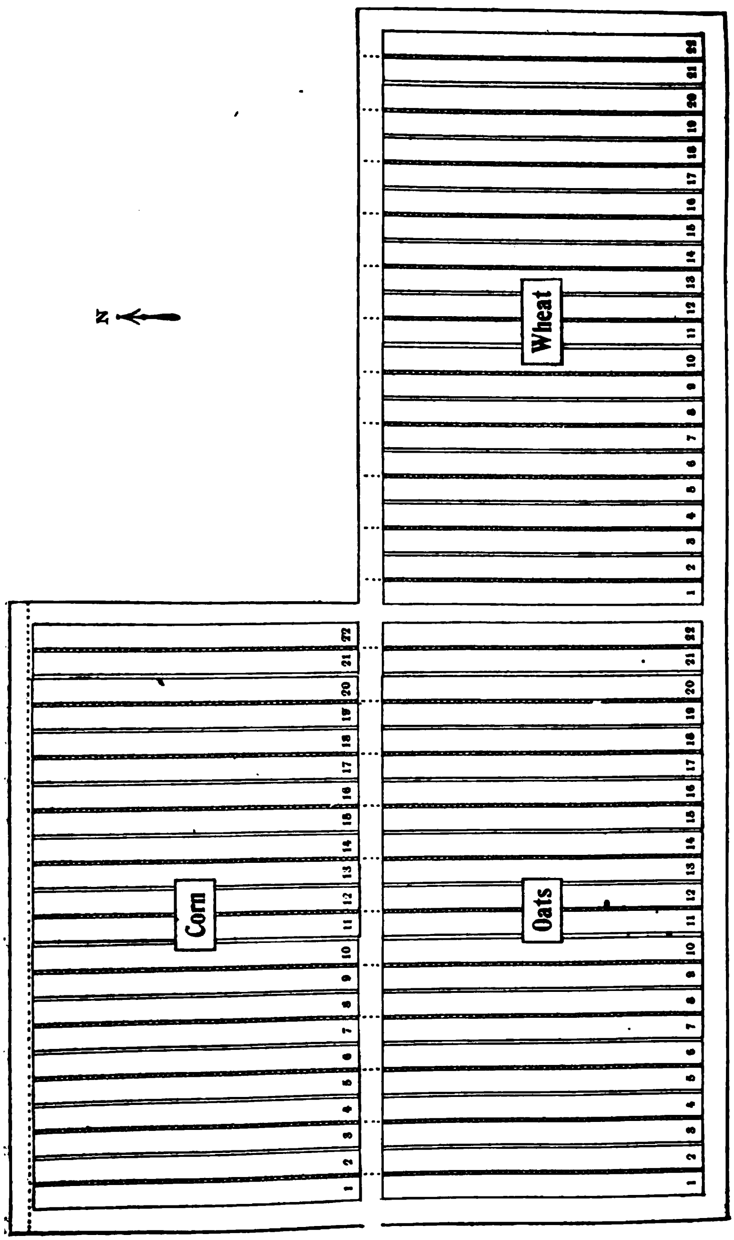


TABLE XI. PLAN OF FERTILIZING ON CROPS GROWN IN CONTINUOUS CULTURE AT COLUMBUS.

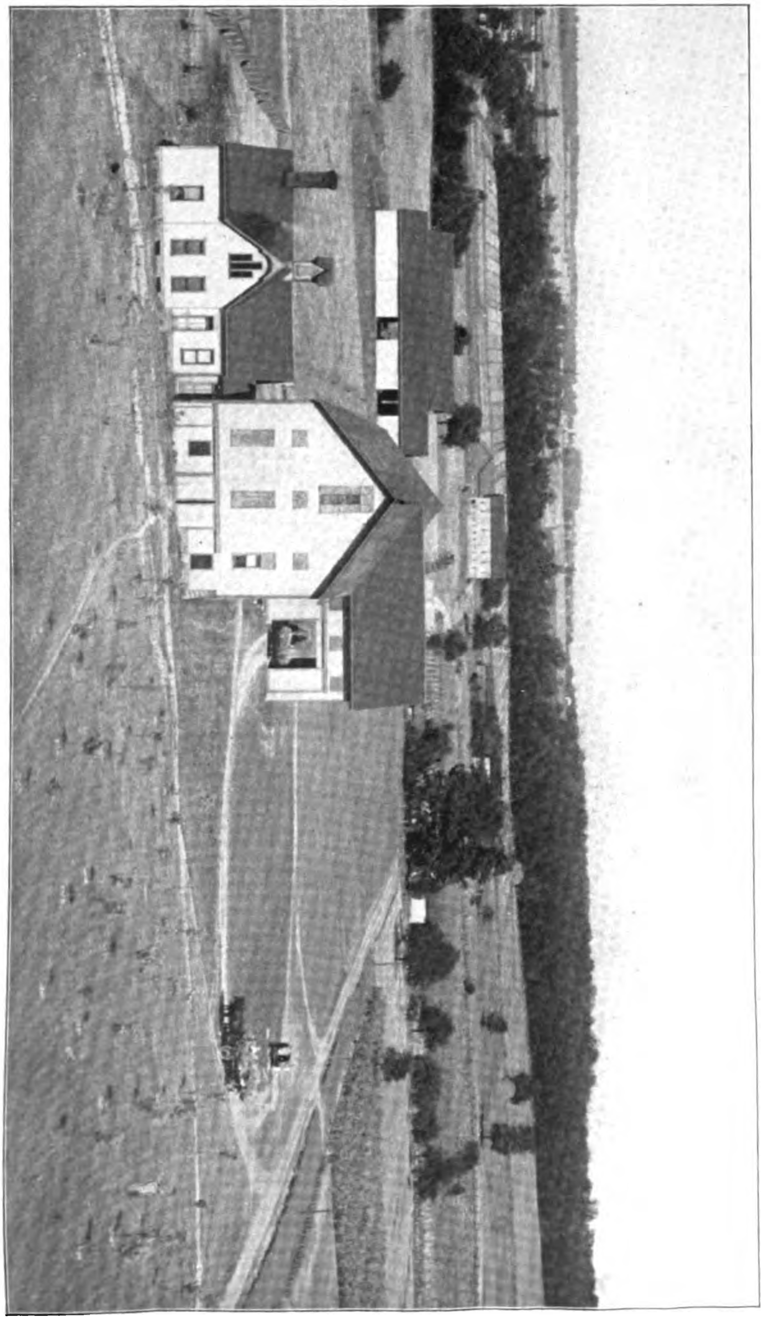
Plot	Fertilizing materials in pounds per acre
1	None.
2	Superphosphate, 320.
3	Muriate of potash, 80.
4	None.
5	Nitrate of soda, *160.
6	Superphosphate, 320; nitrate of soda, *160.
7	None.
8	Superphosphate, 320; muriate of potash, 80.
9	Muriate of potash, 80; nitrate of soda, *160.
10	None.
11	Superphosphate, 320; muriate of potash, 80; nitrate of soda, *160.
12	Superphosphate, 320; muriate of potash, 80; nitrate of soda, *320.
13	None.
14	Superphosphate, 320; muriate of potash, 80; nitrate of soda, *480.
15	Superphosphate, 320; muriate of potash, 80; sulphate of ammonia, 120.
16	None.
17	Acid phosphate, 320; muriate of potash, 80; nitrate of soda, *160.
18	Slag phosphate, 320; muriate of potash, 80; nitrate of soda, *160.
19	None.
20	Barnyard manure, 8 tons.
21	Linseed oil-meal, 1000 lbs.
22	None.

* For wheat, 40 lbs. dried blood, and the remainder nitrate of soda.

TABLE XII. PLAN OF FERTILIZING CORN, GROWN IN CONTINUOUS CULTURE AT EAST LIVERPOOL.

Plot	Fertilizing materials, in pounds, per acre, since 1894. (Half these quantities previously)
1	None.
2	Superphosphate, 640.
3	Muriate of potash, 160.
4	None.
5	Nitrate of soda, 320.
6	Superphosphate, 640; nitrate of soda, 320.
7	None.
8	Superphosphate, 640; muriate of potash, 160.
9	Muriate of potash, 160; nitrate of soda, 320.
10	None.
11	Superphosphate, 640; muriate of potash, 160; nitrate of soda, 320.
12	Barnyard manure, 16 tons.
13	None.
14	Land plaster, 800.

PLATE VII.



Looking east from the tower of the main building in harvest time. Section C of the 5-year rotation, fertilizer tests, in the distance.

TABLE XIII. PLAN OF FERTILIZING CROPS GROWN IN CONTINUOUS CULTURE AT WOOSTER.

Fertilizing materials in pounds per acre.

Plot	On Corn			On Oats			On Wheat			
	Super-phosphate	Muriate of potash	Nitrate of soda	Super-phosphate	Muriate of potash	Nitrate of soda	Super-phosphate	Muriate of potash	Dried blood	Nitrate of soda
1	......	......	......	......	......	......	......	......	......	......
2	160	100	160	160	100	160	160	100	40	120
3	60	30	160	55	50	160	45	30	40	120
4	......	......	......	......	......	......	......	......	......	......
5	A	......	......	A	......	......	A	......	......	......
6	B	......	......	B	......	......	B	......	......	......
7	......	......	......	......	......	......	......	......	......	......
8	160	100	320	160	100	320	160	100	40	280
9	120	60	320	110	100	320	90	60	40	280
10	......	......	......	......	......	......	......	......	......	......

A Barnyard manure, 5,000 lbs. B Barnyard manure, 10,000 lbs.

biana county, which he has continued at his personal expense up to this date. The soil here under test is a thin sheet of clay, not more than twelve to eighteen inches in thickness, lying upon argillaceous shales of the coal measures. These shales have weathered at the surface into the overlying soil, and their loose stratification gives even excessive drainage. It is a soil in which the necessity for maintaining the humus supply has been demonstrated by practical experience. Where it has lain several years in grass it will produce one or two good crops of grain, after which it must be seeded to grass again. The plan of fertilizing in this test is given in Table XII.

Upon the removal of the Experiment Station from Columbus to Wooster an experiment was begun in the continuous culture of the cereals, following the plan of fertilizing given in Table XIII, the object in this test being more particularly to study the ability of the different crops to secure plant food and the relative availability of the chief fertilizing constituents as found in ordinary commercial fertilizers and in barnyard manure. The cropping in this test began in 1894.

In these experiments, therefore, corn has been grown continuously for 12 years at Columbus and East Liverpool, and for 5 years at Wooster (the corn crops of 1899 not being harvested in season to be included here). Oats has been grown 10 years at Columbus and 6 years at Wooster, and wheat has been grown 11 years at Columbus and 6 years at Wooster.

3. Ex. Sta. Bul. 110.

FERTILIZERS ON CORN GROWN IN CONTINUOUS CULTURE.

Table XIV shows the average yield and increase of corn at Columbus for the 11 years, 1888-98.

From this table it is seen at a glance that there has been a falling off in the unfertilized plots, amounting to nearly one-half the grain and more than one-half the stover, over the later period as compared with the earlier one. It also appears that the fertilizers have not been able to materially check this downward tendency, the average increase on the 14 fertilized plots being 237 pounds of ears and 567 pounds of stover for the first period, against 251 pounds of ears and 378 pounds of stover for the second period. Even the annual application of 8 tons of barnyard manure has not been sufficient to maintain the yield, the relative loss on the manured plot being in fact somewhat greater than on some of the fertilized plots.

TABLE XIV. FERTILIZERS ON CORN GROWN CONTINUOUSLY AT COLUMBUS.

Average yield and increase or decrease (—) in pounds per acre.

Plot	5 years, 1888-1892				6 years, 1893-1898				11 years, 1888-1898			
	Yield		Increase		Yield		Increase		Yield		Increase	
	Ears	Stover	Ears	St'v'r	Ears	Stover	Ears	St'v'r	Ears	Stover	Ears	Sto.
1	4,544	4,114	.....	.....	2,225	1,602	.....	.....	3,280	2,744	.....	....
2	4,479	3,779	-118	-286	2,418	1,740	166	89	3,355	2,668	-17	-81
3	4,579	4,438	-69	423	2,827	2,061	347	360	3,623	3,142	160	389
4	4,700	3,966	.....	.....	2,607	1,750	.....	.....	3,558	2,758	.....	....
5	4,935	4,837	311	841	2,906	2,100	305	338	3,829	3,344	309	566
6	5,030	4,643	484	617	2,778	2,102	184	329	3,802	3,257	320	460
7	4,470	4,056	.....	.....	2,588	1,785	.....	.....	3,444	2,817	.....	....
8	4,617	4,371	116	295	2,884	2,328	335	560	3,672	3,256	235	439
9	5,016	4,835	483	738	2,877	2,059	368	309	3,853	3,321	420	504
10	4,564	4,117	.....	.....	2,470	1,733	.....	.....	3,422	2,816	.....	....
11	4,939	4,507	336	362	2,936	2,327	474	603	3,846	3,318	411	494
12	5,050	4,578	409	406	2,886	2,151	434	435	3,870	3,254	422	422
13	4,680	4,200	.....	.....	2,446	1,707	.....	.....	3,870	3,254	422	422
14	4,886	4,666	368	732	2,608	2,135	250	452	3,643	3,286	303	580
15	4,568	4,718	213	[1]935	2,776	2,246	503	587	3,591	3,235	371	[2]726
16	4,193	3,402	.....	.....	2,187	1,635	.....	.....	3,099	2,438	.....	....
17	4,725	4,471	571	978	2,626	2,002	456	380	3,580	3,125	508	652
18	4,705	4,277	591	692	2,608	1,991	455	381	3,562	3,030	517	523
19	4,075	3,676	.....	.....	2,136	1,597	.....	.....	3,018	2,542	.....	....
20	4,738	4,000	433	277	2,561	1,861	388	234	3,550	2,833	408	254
21	5,151	4,699	617	930	2,563	1,780	354	124	3,739	3,107	472	490
22	4,764	3,816	.....	.....	2,246	1,686	.....	.....	3,391	2,654	.....	....
*	4,499	3,918	.....	.....	2,363	1,687	.....	.....	3,334	2,701	.....	....

[1] 4 years.
[2] 10 years.
* Average unfertilized yield.

TABLE XV. FERTILIZERS ON CORN GROWN CONTINUOUSLY AT EAST LIVERPOOL.

Average yield and increase in pounds per acre.

Plot	5 years, 1888–1892				6 years, 1893–1898				11 years, 1888–1898			
	Yield		Increase		Yield		Increase		Yield		Increase	
	Ears	Stover	Ears	St'v'r	Ears	Stover	Ears	St'v'r	Ears	Stover	Ears	S'v'r
1	2,053	2,737	.....	.....	813	1,302	.....	.....	1,377	1,951	.....	....
2	2,081	2,850	-106	87	780	1,181	-42	-132	1,372	1,940	-71	-32
3	2,246	3,078	-76	289	890	1,276	58	-47	1,506	2,095	-3	107
4	2,456	2,815	.....	.....	841	1,334	.....	.....	1,575	2,007	.....	....
5	3,139	3,363	498	500	1,002	1,392	138	-1	1,972	2,288	300	227
6	3,412	3,468	586	557	1,252	1,744	364	293	2,234	2,528	466	413
7	3,011	2,959	.....	.....	911	1,510	.....	.....	1,865	2,169	.....	....
8	2,631	3,459	-347	464	954	1,326	17	-225	1,716	2,295	-148	87
9	3,566	3,740	621	709	1,270	1,757	308	164	2,313	2,659	450	412
10	2,912	3,067	.....	.....	988	1,634	.....	.....	1,862	2,286	.....	....
11	3,107	3,565	278	514	1,641	2,261	666	632	2,308	2,854	490	578
12	3,044	3,559	296	524	1,633	2,333	672	710	2,274	2,890	501	625
13	2,665	3,019	.....	.....	948	1,618	.....	.....	1,728	2,255	.....	....
14	2,512	2,997	-153	-22	902	1,382	-46	-236	1,633	2,115	-95	-140
*	2,619	2,919	.....	.....	900	1,480	.....	.....	1,681	2,134	.....	....

*Average unfertilized yield.

TABLE XVI. YIELD OF CORN GROWN IN CONTINUOUS CULTURE COMPARED WITH AVERAGE COUNTY YIELD.

Yield of car-corn in bushels per acre.

Year	Columbus			Franklin County	East Liverpool			Columbiana County
	Unfertilized	Plot 11	Plot 20		Unfertilized	Plot 11	Plot 12	
1888	81.5	75.8	79.5	43.2	52.4	71.1	58.5	38.0
1889	58.3	67.4	62.8	29.4	57.7	64.7	73.3	35.8
1890	43.6	48.1	44.9	31.5	22.0	24.3	29.7	27.4
1891	57.3	69.5	62.7	38.3	27.7	30.6	28.0	33.6
1892	65.4	76.0	70.3	40.7	19.1	23.7	21.7	32.1
5-year average	61.2	67.4	64.0	36.6	35.8	42.9	42.2	33.4
1893	38.6	41.2	39.8	35.0	7.6	9.3	6.9	30.3
1894	42.7	51.5	40.6	37.0	......	......	......	22.6
1895	21.3	19.1	30.5	36.0	28.2	51.5	54.7	40.0
1896	46.8	56.4	47.9	41.9	30.2	43.5	43.0	39.9
1897	34.2	43.0	44.4	37.1	......	......	......	30.3
1898	18.9	29.0	27.7	37.0	11.1	36.1	35.4	42.4
6-year average	33.7	40.0	38.5	37.3	12.8	23.4	23.3	34.3

Turning to the test at East Liverpool, as exhibited in Table XV, we find a very similar condition of affairs. In this test there was a rapid decline in yield from the beginning, and the crop of 1894 was so complete a failure that no attempt was made to harvest the grain separately. The quantities of fertilizers and manure were then doubled for 1895 and succeeding seasons, and yet these heavy applications were not able to restore the yield to that of the first two years of the test. In fact, there was a second failure of crop in 1897, when no grain was harvested, the total yield for this season amounting to less than 400 pounds per acre on plots 11 and 12.

Table XVI gives the actual yields, in these two tests, of the average of the unfertilized plots, of Plot 11, receiving the complete fertilizer, and of the manured plot, over the two periods under consideration, as compared with the average yield for the same periods of the two counties in which the tests are located, as reported by the township assessors:

It will be observed that in both tests the unfertilized yield is greater than the average yield of the county over the first period, but smaller over the second; that the yield of the fertilized and manured plots is conspicuously greater than the average yield of the county over the first period, but is only slightly greater at Columbus and very much smaller at East Liverpool over the second. In both cases the county yields are slightly greater over the second period than over the first.

Farmers on upland soils have long since learned that corn grows best on a decaying sod, and it is the general custom, in such regions, to practice a more or less systematic rotation, in which corn follows grass or clover. In the rich bottom lands of the river valleys, however, this necessity for rotation has not been so strongly enforced, and in these regions of the state there are many fields which are planted in corn continuously, year after year.

The soils of Columbiana county are almost exclusively upland, its few valleys being quite narrow, and the general practice is to turn under an old, blue-grass sod, grow one or two crops of corn on it, and then seed down to grass again with wheat. This practice is, of course, not universally followed; there are many careless farmers who do not heed the lessons of experience and whose meager crops reduce the general average. Comparing the yields obtained in the test at East Liverpool with those of Columbiana county, we see that for the first two seasons the unfertilized yield in this test considerably exceeds the average yield of the county, but with the third crop it falls behind and loses ground constantly from that time forth. The fertilized and manured plots make a little better record, but even the large dressing of 16 tons of barnyard manure per acre is only temporarily able to bring up the yield to that of the county.

Franklin county is very different in topography and character of soil from Columbiana. The entire county is covered with the drift of the

glacial epoch, giving a soil rich in all the mineral elements of fertility, while it is traversed by five considerable streams, three of which cross the entire county from north to south, and all of which, with their numerous smaller tributaries, have wide flood plains along a considerable part of their course. Between some of these valleys lie broad "second bottoms" of gravelly soil—the flood plains of the ancient glacial rivers—which are quite as productive, when properly handled, as the bottoms themselves, while at a little higher elevation are beds of bowlder clay, rich in the mineral constituents of fertility (see analysis, p. 6), but requiring under-drainage to make their stores available.

The potential corn production of this entire county, we believe, is only fairly represented by the yields in this test over the first period, which, it will be seen, are far above the average yields of the county; the possible yields of the latter being not attained because of continuous cropping on the bottom lands, and lack of drainage on the uplands.

It will be observed that it is not until the eighth year of continuous cropping, in the test under consideration, that the yield falls below that of the county, while for the first two seasons it is almost double that of the county.

It seems apparent, from this test, that the present need of this soil for corn production is not so much the addition of purchased fertility, as the systematic practice of drainage and crop rotation, including the culture of nitrogen gathering crops.

The natural conditions of Franklin county are, in greater or less degree, typical of a vast region occupying the western and southwestern portions of the state; the region including the valleys of the Miamis, the Scioto, and a large portion of the Muskingum, with the great drift plains lying between.

The experiment in the continuous culture of corn at Wooster differs from those previously considered in having been commenced on a soil already depleted of fertility. The land had been in wheat in 1892—the last year of a long term of tenant farming. There was, therefore, no such store of accumulated fertility to begin upon as in the case of the clover sod at Columbus, or the old, blue-grass sod at East Liverpool. In the spring of 1893 it was underdrained and planted to corn, the work of draining delaying the corn planting to a late date and the crop was harvested simply as fodder.

The average yield of the five crops, harvested 1894 to 1898, is given in Table XVII, and in Table XVIII is given a comparison of the yields in this test and also in the rotative cropping with those in Wayne county over the same period. From this table it appears that the unfertilized yield on this thin soil is far below the average yield of the county, while the yield on the fertilized and manured plots is considerably above that of the county. In comparing the plans of fertilizing in the different tests it will be seen that Plots 2 and 8, in this test, receive the same quantity of

TABLE XVII. FERTILIZERS ON CORN GROWN CONTINUOUSLY AT WOOSTER.

Fertilizers, yield and increase in pounds per acre.

Plot	Fertilizers per acre annually			5-year average yield and increase			
	Super-phosphate	Muriate of potash	Nitrate of soda	Yield		Increase	
				Ear-corn	Stover	Ear-corn	Stover
1	....	....	....	2,043	1,449	....	....
2	160	100	160	3,123	2,076	1,087	631
3	60	30	160	2,720	1,770	692	330
4	....	....	....	2,020	1,436	....	....
5	*	....	....	2,551	1,670	608	278
6	**	....	....	3,019	1,938	1,154	590
7	....	....	....	1,787	1,304	....	....
8	160	100	320	3,110	2,008	1,418	749
9	120	60	320	2,993	1,870	1,397	655
10	....	....	....	1,501	1,170	....	....
Average unfertilized yield				1,838	1,340	....	....

* Barnyard manure, 5,000 lbs. per acre
** Barnyard manure, 10,000 lbs. per acre.

TABLE XVIII. YIELD OF CORN GROWN AT THE EXPERIMENT STATION COMPARED WITH AVERAGE COUNTY YIELD.

Yield per acre in bushels of 70 pounds of ears.

Year	Yield at Experiment Station, Wooster						Yield of Wayne county
	Continuous culture			Rotation			
	Average unfertilized	Plot 2 complete fertilizer	Plot 6 barnyard manure	Average unfertilized	Plot 11 complete fertilizer	Plot 18 barnyard manure	
1894	16.5	24.8	23.1	18.6	20.5	17.8	24.9
1895	28.3	38.2	47.5	35.4	42.1	*37.2	37.9
1896	48.8	73.2	68.8	52.0	68.6	58.7	40.5
1897	10.0	29.6	25.6	25.9	33.9	46.0	37.6
1898	28.0	57.1	50.6	27.6	41.4	40.4	42.0
Average	26.3	44.6	43.1	31.9	41.3	40.0	36.6

* Plot 20.

nitrogen, with half the phosphoric acid and a little more potash than is given to Plots 11 and 12, in the test at Columbus; and Plot 6, in the Wooster test, receives 6 tons of manure, while Plot 20 at Columbus receives 8 tons. It will be observed that the unfertilized yield in this test is considerably smaller than that of the Columbus test over the last six years, while the yield on the fertilized and manured plots is considerably larger. But the yield for Wayne county in general is only seven-tenths of a bushel less than that for Franklin county; it would appear, therefore, that the Wayne county soil has responded more effectively to both fertilizer and manure than that at Columbus.

FERTILIZERS ON OATS GROWN CONTINUOUSLY ON THE SAME LAND.

An experiment in the continuous culture of oats, with and without manure and fertilizers, was begun in 1889 on the farm belonging to the State University at Columbus, the land devoted to this test being of the same general character and previous history as that carrying the test in continuous corn culture just described. The land was underdrained in the spring of 1888, the work being completed in time for planting corn, but too late for oats, so a crop of millet was grown that season, without fertilizer, and the experiment with oats was begun the following spring. The plan of fertilizing is given in Table XI, the plots of the same number being continuous through oats and corn, as are the tile drains, which are laid under alternate dividing spaces (See Diagram VIII). The entire tract slopes gently to the North. The record in this test has unfortunately been broken in the case of several of the plots, so that a complete average of the yield for the entire period can only be given for Plots 4 to 16 inclusive. This is given in Table XIX, which includes also the average yield of the two 5-year periods, 1889-1893 and 1894-1898 inclusive.

From this table we see that nitrogen has apparently been the most effective of the three chief fertilizing constituents, when used separately, but that the effect is increased by the addition of phosphoric acid or potash. When these are used without nitrogen, however, their effect is very small. The largest average yield of grain in this test has been produced on Plot 12, receiving 320 pounds of nitrate of soda yearly; the total yield of grain and straw however, is slightly larger on Plot 14, receiving 480 pounds of nitrate of soda. This large application frequently caused the oats to lodge and thus much of the possible effect was lost.

It will be observed that no fertilized plot gives as large an average yield during the second period as during the first. The yield of grain on the manured plot is practically the same, but there is a considerable falling off in the yield of straw.

The experiment in the continuous culture of oats at Wooster was begun in 1894, on land adjoining that devoted to the similar experiment

TABLE XIX. FERTILIZERS ON OATS GROWN CONTINUOUSLY AT COLUMBUS.

Yield and increase in pounds per acre

Plot	5 years, 1889–1893				5 years, 1894–1898				10 years, 1889–1898			
	Yield		Increase		Yield		Increase		Yield		Increase	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Str'w
1												
2									[1]974	2182	21	248
3									[2]1078	2286	125	352
4	1043	2430			862	1438			953	1934		
5	1189	2750	147	345	1004	1921	155	490	1097	2335	151	417
6	1227	2711	186	331	1152	2074	316	650	1189	2392	250	490
7	1040	2355			823	1417			932	1886		
8	1140	2705	58	252	957	1583	111	178	1048	2144	84	215
9	1265	2855	142	304	1104	2068	235	676	1184	2461	188	490
10	1165	2649			892	1380			1028	2014		
11	1365	2949	179	281	1112	2371	222	942	1239	2673	201	612
12	1363	3078	155	391	1229	2676	341	1197	1296	2877	249	794
13	1229	2706			886	1528			1057	2117		
14	1304	2955	118	391	1186	2888	319	1389	1245	2922	219	890
15	1305	2867	162	444	1148	2362	301	891	1227	2619	331	668
16	1100	2281			828	1442			964	1861		
17									[3]1193	2405	211	567
18									[3]1187	2362	201	508
19									[4]996	2149		
20	1151	2673	91	289	[6]1149	2388	240	577	[5]1133	2546	157	417
21									[5]1073	2665	128	449
22												
	1115	2484	143	342	858	1441	250	802	988	1993		

[1] 9 years, excluding 1893. [2] 9 years, excluding 1894. [3] 8 years, excluding 1893 and 1896. [4] 8 years, excluding 1898 and 1895. [5] 9 years, excluding 1896. [6] 4 years, excluding 1895.

TABLE XX. FERTILIZERS ON OATS GROWN CONTINUOUSLY AT WOOSTER.

Fertilizers, yield and increase in pounds per acre.

Plot	Fertilizers per acre annually			6-year average yield and increase			
	Super-phos-phate	Muriate of potash	Nitrate of soda	Yield		Increase	
				Grain	Straw	Grain	Straw
1				845	852		
2	160	100	160	1372	1701	507	795
3	55	50	160	1272	1465	387	505
4				905	1014		
5	*			992	1011	88	—19
6	**			1145	1300	242	252
7				902	1065		
8	160	100	320	1642	2183	729	1107
9	110	100	320	1572	2065	647	977
10				936	1099		
Average unfertilized yield				897	1007		

* Barnyard manure, 5,000 pounds per acre. ** Barnyard manure, 10,000 pounds per acre.

with corn. The average results for the six years, 1894-99, are given in Table XX.

Comparing the yields, as given in this table, with those obtained at Columbus, we see that with oats, as with corn, the unfertilized yields at Wooster are far below those at Columbus during the first five years of the experiment there, but approximate those of the second 5-year period. The ratio of straw to grain is much larger at Columbus than at Wooster, and the effect of the fertilizers is found chiefly in the straw at Columbus and more largely in the grain at Wooster. While the unfertilized yield of grain is but little larger at Wooster than at Columbus, during the second period, the yield on Plots 2 and 8 at Wooster is materially greater than that of the similarly fertilized Plots 11 and 12 at Columbus, although the yield of straw remains regularly larger at Columbus than at Wooster. In the case of the manured plots, however, there is no practical difference between the yields of grain over the two periods at Columbus, nor between these yields and that at Wooster, although in this case again the straw yield runs much larger at Columbus. This difference in yield of straw will be again referred to in discussing the experiments on wheat.

The yields in the two experiments, as compared with the average yields over similar periods for the counties within which they are located, are given below:

TABLE XXI. YIELDS PER ACRE OF OATS IN EXPERIMENTS, COMPARED WITH COUNTY YIELDS.

Place and period	Experiment station				County
	Unfertilized	Nitrate of soda 160 lbs.	Nitrate of soda 320 lbs.	Barnyard manure	
Columbus:—		Plot 11	Plot 12	Plot 20	Franklin
5 years, 1889–1893	34.8	42.7	42.6	36.0	22.3
5 years, 1894–1898	26.8	34.8	38.4	35.9	26.3
Wooster:—		Plot 2	Plot 8	Plot 6	Wayne
5 years, 1894–1898 ...	30.9	42.9	48.7	45.4	36.3

It appears that the yield of oats in Franklin county has shown a marked increase during the second period of this test, while that in the experiment at Columbus has fallen off in every case except on the plot treated with barnyard manure, and here the failure to show a decline in yield may be ascribed to the relatively low yield during the first period. The unfertilized yield in the experiment, however, remains slightly above the yield of the county, while the fertilized yield is considerably higher.

In the experiment at Wooster the unfertilized yield falls below the average yield of Wayne county, but the fertilized yield is here, as at Columbus, considerably higher than the yield of the county.

It will be observed that the yield of Wayne county is much higher than that of Franklin county, a fact due chiefly to climatic causes. The yields of both oats and wheat in Ohio regularly increase in passing from the southern to the northern parts of the state.

In considering these comparative yields it is important to take into account the methods usually followed in the cultivation of oats in Ohio. As a rule this crop is sown upon corn stubble, and it is a common practice, especially in the southern part of the state, to sow the seed grain broadcast on the unplowed corn stubble and cover it in with corn cultivators. On low, black or sandy soils this method may be a useful one, but in the cultural experiments of this Station the yield of oats has been increased by 50 per cent. by more thorough preparation of the seed bed.*

The relatively low yield of Franklin county, as compared with the unfertilized yield in the long continued experiment in that county, is most probably chiefly due to the method of seeding indicated, the seed bed in the experiment having been thoroughly prepared each spring by plowing and harrowing, the grain being then sown with the drill.

The yield of Wayne county, however, lies between the unfertilized and the fertilized yields of the experiment at Wooster. Taking the five years, 1894 to 1898, the fertilized plots at Wooster show practically the same increase over the similarly fertilized plots at Columbus as is shown by the yield of Wayne county over that of Franklin.

The comparison as a whole confirms that of the experiments with corn in showing that the soil at Wooster is more responsive to fertilizers than that at Columbus.

FERTILIZERS ON WHEAT GROWN CONTINUOUSLY ON THE SAME LAND.

The experiment in the continuous culture of wheat was begun at Columbus with the crop sown in the fall of 1888. The land occupied by this test lies adjoining that devoted to corn and oats, but is farther from the river, and instead of having the gravelly subsoil found under the corn and oats plots the soil of the wheat plots rests directly upon the bowlder clay of the glacial drift. The land was in clover in 1888. In 1889 the wheat averaged nearly 43 bushels per acre on the unfertilized plots; in 1890 and 1891 these plots produced over 31 bushels per acre; in 1892 and 1893, 26½ bushels; in 1894 the crop fell to 16.3 bushels, and in 1895 and 1896 it suffered from the general destruction from winter killing, which prevailed over the state at large, especially on clay lands. In 1895 the yield fell to less than two bushels; and in 1896 the destruction was practically complete, both on the fertilized plots and where barnyard manure had been liberally used for eight years in succession.

* Bulletin 101.

Up to this year the fertilizers and manure had been regularly applied according to the plan given on page 28, making 8 successive applications; but at this point it was decided to stop fertilizing the wheat crop in this test for a few years, in order to study the residual effect of the previous applications. The crop of 1897 was a large one, the unfertilized yield averaging 39 bushels per acre; that of 1898 averaged nearly 20 bushels and that of 1899 fell to 13.7 bushels. In Table XXII are given the average yields and increase in this test for the first seven years, and for the three years since the fertilizing was stopped.

The table shows that the increase of grain in this experiment has been small, that for the complete fertilizers amounting to only five or six bushels per acre during the years while the fertilizers were being applied; while potash alone has increased the crop by less than one bushel, nitrogen alone by but little more than a bushel, and phosphoric acid alone by a fraction over three bushels. With the straw, however, the case is quite different. On the unfertilized plots 97 pounds of straw has carried on the average a bushel of grain. Had this ratio of grain to straw been maintained on the fertilized plots the increase of grain on Plots 11 and 12 would have amounted to more than four times that actually found, or to 24 or 25 bushels per acre, and that on the manured plots would have exceeded 20 bushels.

It will be observed, moreover, that the phosphoric acid of the fertilizer has been at least an equal factor with the nitrogen in increasing the weight of straw. From the second year of the test the plots receiving superphosphate have become conspicuous by their taller growth within two or three weeks after the grain was sown, and have remained so until harvest. This improvement has been most distinctly marked in the straw, however; the foliage has remained pale, and on Plots 2 and 8 the plants have had a spindling, anæmic appearance, while even on those plots which had had a small dressing of dried blood in the fall, following a larger application of nitrate of soda each spring before, the plants took on a much darker color and showed a more vigorous growth when the nitrate was again applied in April. The smaller applications of nitrate of soda have seldom caused the grain to lodge, but lodging has been frequent on Plot 12, and so common on Plot 14 as to reduce the total weight of straw both by the longer stubble left and by actual deterioration of the plant. On this plot the effort has been made to overcome the tendency to lodge by distributing the applications of nitrate, but without any evident effect. It has seemed that this tendency to lodge was due more largely to increased weight of foliage than to larger growth of straw. Turning to the later years of the test, it appears that the increase found since the discontinuance of the fertilizers has been chiefly due to the phosphoric acid. Instead of an increase an actual decrease of crop is found on the plots which had received nitrogen and potash alone, but there seems still to be a further increase where both were added to the phosphoric acid.

TABLE XXII. FERTILIZERS ON WHEAT GROWN CONTINUOUSLY AT COLULBUS.

Average yield and increase or decrease (—) in pounds per acre.

Plot	7 years, 1889 to 1895				3 years, 1897 to 1899			
	Yield		Increase		Yield		Increase	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
1	1,652	2,830	....	....	1,563	2,457	....	....
2	1,796	3,278	192	572	1,723	2,830	200	509
3	1,601	2,521	47	—60	1,471	2,146	—12	—40
4	1,506	2,457	....	....	1,443	2,050	....	....
5	1,625	2,699	76	180	1,374	2,129	—100	—15
6	1,705	3,270	112	689	1,637	2,526	133	288
7	1,636	2,643	....	....	1,535	2,332	....	....
8	1,772	3,182	162	595	1,839	2,844	328	573
9	1,763	3,106	179	575	1,603	2,416	117	207
10	1,558	2,476	....	....	1,462	2,148	....	....
11	1,877	3,889	327	1412	1,731	2,876	264	678
12	1,912	3,949	370	1472	1,805	2,885	334	638
13	1,535	2,477	....	....	1,476	2,297	....	....
14	1,860	3,751	347	1321	1,760	2,743	334	572
15	1,781	3,357	290	976	1,604	2,566	227	521
16	1,469	2,334	....	....	1,327	1,919	....	....
17	1,741	3,184	284	882	1,492	2,325	122	280
18	1,764	3,261	320	992	1,657	2,622	245	450
19	1,432	2,236	....	....	1,455	2,298	....	....
20	1,775	3,356	384	1205	1,835	3,172	421	964
21	1,702	3,079	352	1011	1,443	2,293	70	174
22	1,310	1,985	....	....	1,332	2,028	....	....
*	1,512	2,430	....	....	1,449	2,191	....	....

* Average of unfertilized plots.

The increase on the plot dressed with barnyard manure is greater than during the years when it was annually applied, and this not because of falling off in yield of unfertilized plots, but because the actual yield is greater.

The effect of phosphoric acid upon the wheat crop is quite different from that observed upon the corn and oats crops in this experiment, but it would seem that this difference is rather due to differences in soil than to preferences of crop, for we find in the experiments at Wooster and Strongsville no such differences in the effect of phosphoric acid upon these crops as that observed here.

A probable explanation of this difference at Columbus lies in the fact, already referred to, that the corn and oats have grown upon a soil lying upon and chiefly formed from a terrace-kame, the gravels of which contain a considerable proportion of limestone, brought down from the upper beds of the Corniferous limestone, which the Olentangy river cuts into a few miles above. One of the upper layers of this limestone has been shown by the late Edward Orton, State Geologist, to be so largely

TABLE XXIII: FERTILIZERS ON WHEAT GROWN CONTINUOUSLY AT WOOSTER.

Fertilizers, yield and increase in pounds per acre.

Plot	Fertilizers per acre annually			6-year average yield and increase			
				Yield		Increase	
	Super-phos-phate	Muriate of potash	Nitrate of soda and dried blood	Grain	Straw	Grain	Straw
1	....	....	....	556	1175	....	....
2	160	100	160	1172	2183	619	1083
3	45	30	160	923	1632	375	609
4	....	....	....	545	947	....	....
5	*	....	....	743	1383	201	428
6	**	....	....	897	1688	356	726
7	....	....	....	538	970	....	....
8	160	100	320	1261	2491	723	1516
9	90	60	320	1118	2084	590	1104
10	....	....	....	523	985	....	....
Average unfertilized yield				541	1019	....	....

* Barnyard manure, 5,000 pounds per acre.
** Barnyard manure, 10,000 pounds per acre.

TABLE XXIV: COMPARISON OF YIELDS OF WHEAT GROWN CONTINUOUSLY IN STATION EXPERIMENTS WITH AVERAGE COUNTY YIELDS.

Yields in bushels per acre.

Year	Columbus			Frank-lin county	Wooster			Wayne county
	Unfer-tilized	Plot 11	Plot 20		Unfer-tilized	Plot 2	Plot 6	
1889	42.8	49.5	44.5	13.3	......	......	......	20.3
1890	31.1	36.9	34.7	14.2	......	......	......	18.0
1891	31.4	28.8	27.3	17.0	......	......	......	15.6
1892	26.5	29.1	25.4	16.0	......	......	......	14.1
1893	26.4	38.6	37.3	16.1	......	......	......	21.9
1894	16.3	23.7	25.3	13.1	......	......	......	22.0
6– year average...	29.1	34.4	32.4	14.9	......	......	......	18.6
1895	1.9	12.4	12.5	9.6	4.9	14.8	10.5	10.3
1896	0.0	0.0	0.0	2.2	1.1	6.1	5.3	6.2
1897	39.1	37.5	35.0	18.2	20.4	32.8	29.1	21.4
1898	19.7	24.6	31.7	13.8	11.7	26.2	20.6	16.7
1899	13.7	24.4	25.1	*15.0	3.7	18.2	10.8	*16.0
5– year average...	14.9	19.8	20.9	11.8	8.4	19.6	15.3	14.1

* October estimates of the State Department of Agriculture.

composed of the remains of the teeth, plates and bones of fishes as to merit the name of "bone bed." It is only about 6 inches in thickness, and its analysis indicates only about 17 per cent. of bone phosphate, hence it offers little encouragement to the exploiter of mineral phosphates, in the face of the enormous deposits of rocks showing a much higher percentage of phosphoric acid which are found in the southern states, but it will be seen that it may exert a notable influence on soils situated like the one here described.

Table XXIII gives the results of the experiment in the continuous culture of wheat at Wooster and shows a far lower rate of yield than that shown at Columbus in Table XXII; that table, however, excludes the year of most complete destruction, 1896, from the averages. In Table XXIV is given a comparison of the yields in these two experiments, both with each other and with the average yields of the counties in which they are located, the yields for 1896 being included. The yield at Wooster for 1894 has been excluded from this comparison, because all the seed wheat sown for the crop of that year at Wooster was treated with copper sulphate to destroy the smut, with the result that while the smut was completely eradicated the vitality of much of the seed was also destroyed and the crop was greatly reduced in consequence.

It appears from Table XXIV that the average unfertilized yield of the wheat grown continuously at Columbus was nearly double that of Franklin county during the first six years of this test and has been 25 per cent. greater during the last five years. The table also shows that during the period when both tests were in progress, the unfertilized plots at Columbus have out-yielded the similarly treated plots at Wooster by more than 75 per cent; but the complete fertilizer, applied to Plot 11 at Columbus and Plot 2 at Wooster, has brought up the yield to practically the same point in both tests, thus suggesting again the greater responsiveness to fertilizers of the Wayne county soil. The barnyard manure, however, shows as yet a larger yield at Columbus; but it must be remembered that the quantity used there is one-third larger than at Wooster, and that it had been applied continuously at Columbus for five years before the test began at Wooster. During the five years of the test at Wooster the manured plot has slightly surpassed in yield the average wheat field of Wayne county, while the unmanured plots have fallen far below that average. This point is explained by the comparatively run down condition of the soil on which the experiment is located, and by the fact that the farmers of Wayne county have purchased annually, during the period under consideration, about 80 pounds of commercial fertilizer for every acre sown, which has been practically all applied to the wheat crop.

Following our previous comparisons of continuous with rotative cropping, and of the experimental crops with average county yields, let us consider Table XXV, in which the average yields of the three experi-

TABLE XXV. YIELD OF WHEAT IN ROTATION IN STATION EXPERIMENTS AS COMPARED WITH YIELD OF WAYNE COUNTY.

Yield in bushels per acre.

Year	Continuous culture			5-year rotation			3-year rotation			Wayne Co.
	Unfertilized	Plot 2	Plot 6	Unfertilized	Plot 11	Plot 18	Unfertilized	Plot 11	Plot 18	
1895 ..	4.9	14.8	10.5	3.0	10.8	6.4	7.5	16.2	9.7	10.3
1896 ..	1.1	6.1	5.3	1.1	9.0	7.0	7.4	15.2	11.8	6.2
1897 ..	20.4	32.8	29.1	10.4	30.6	17.4	34.2	45.0	34.3	21.4
1898 ..	11.7	26.2	20.6	12.6	33.7	15.5	23.0	33.2	27.9	16.7
1899 ..	3.7	18.2	10.8	6.9	22.8	15.8	25.9	39.0	33.1	*16.0
Aver'e	8.4	19.6	15.3	6.8	21.4	12.4	19.6	29.7	23.4	14.1

ments at Wooster, thus far considered, are compared with each other and with the average yield of Wayne county.

It appears from this table that the average yield of wheat grown in the longer rotation has been even lower than that grown continuously on the same land; but this is chiefly due to the low yield of the rotative wheat in 1897, when it grew upon Section E, the poorest of the five sections in this test. It could not be expected, however, that there would be much superiority shown at this stage of the test, in a rotation in which there is but one year of clover to four years of exhaustive cereal cropping. When we compare either of these tests with the shorter rotation, a marked difference is at once apparent. The unfertilized yield here is more than double that in either of the other tests, and more than one-third greater than the average yield of the county, while the yield of the manured plot is 60 per cent., and that of the fertilized plot more than 100 per cent. greater than that of the county.

The superior yield of the crops grown in this shorter rotation, however, cannot be altogether ascribed to the method of culture. As has already been stated, the land employed in this rotation was in part (about half) cleared from the forest at the beginning of this test, while the remainder has been managed by a careful owner, whereas that used in the longer rotation had been rented for many years. That the two soils did not originally differ materially in productiveness is shown by the following facts:

The first crop grown in the longer rotation was corn, grown on Section C in 1893.* In recording the yields of the unfertilized plots in this crop it was observed that they ran uniformly at about 20 bushels per acre until No. 28 was reached, when the yield suddenly rose to 34 bushels. A careful examination of the field indicated that there had, at one time,

* This crop has not been included in the general averages heretofore given, because of changes in the plan of fertilizing for subsequent crops.

been a lane across the field at this point—an extension of the road shown on the farm map accompanying—which led from the barn (No. 7) to the wooded ravine east of the plots. Upon inquiry of the former owners of the land it was learned that there had been such a lane but that it had been abandoned and thrown into the field some seven years before the land came into possession of the Station. The comparative yields of Plot 28 and of the unfertilized plots which had been under constant cropping since the original clearing away of the forest, are shown in Table XXVI, to which is added a column showing the average yield of the several seasons for Wayne county.

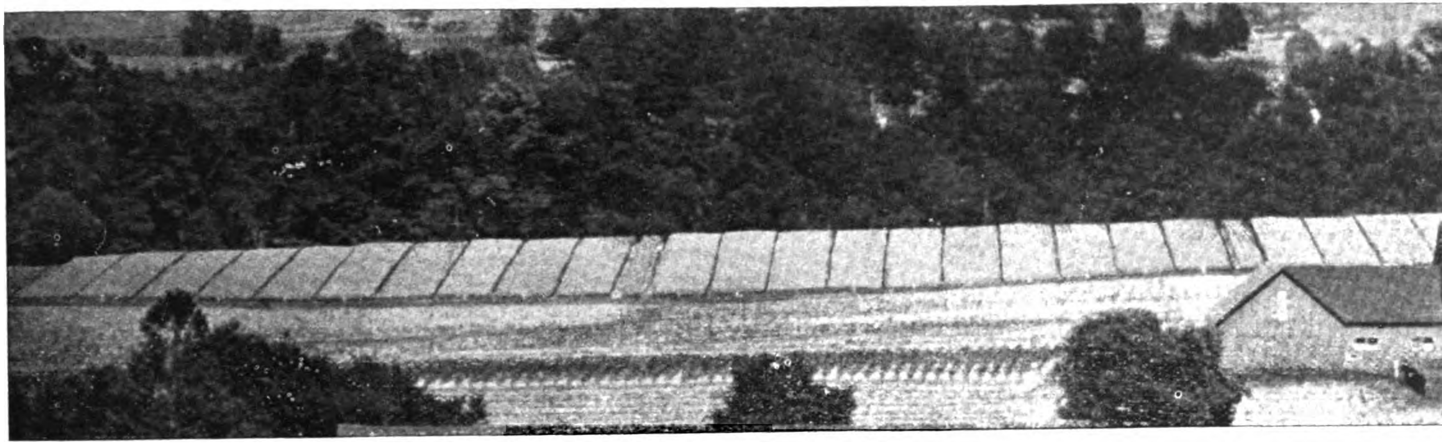
TABLE XXVI. COMPARISON OF UNFERTILIZED PLOTS WITH COUNTY YIELDS

Year	Crop	Yield per acre		
		Unfertilized plots		Wayne county
		28	1 to 25	
1893	Corn	34.0 bus.	20.1 bus.	22.4 bus.
1894	Oats	35.8 "	24.5 "	35.2 "
1895	Wheat	7.2 "	2.5 "	10.3 "
1896	Clover hay	2400 lbs.	1390 lbs.	2400 lbs.
1897	Timothy	2800 "	2558 "	2960 "
1898	Corn	44.9 bus.	25.7 bus.	42.0 bus.
1899	Oats	33.9 "	31.4 "	†42.0 "

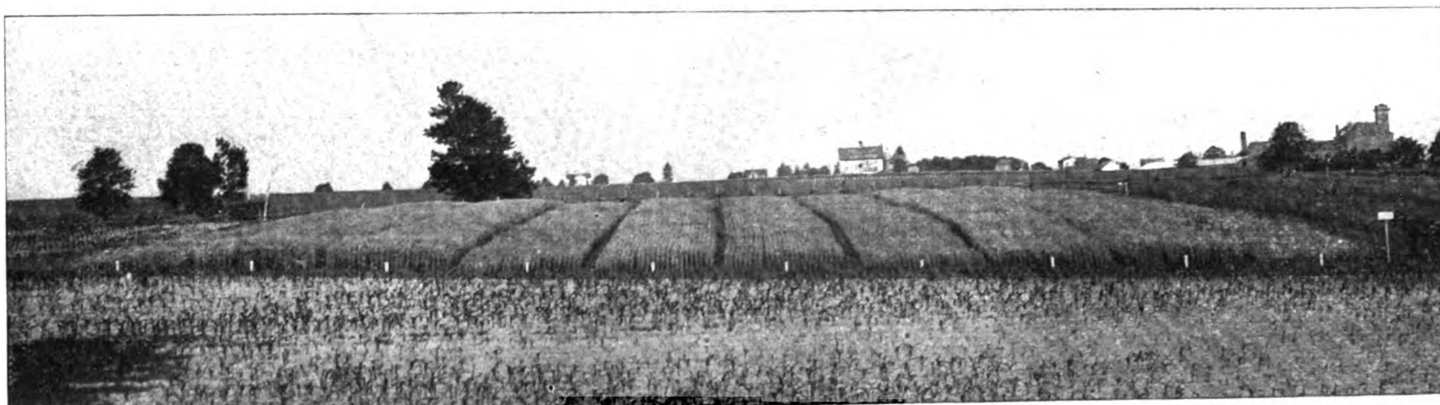
† October estimate, State Department of Agriculture.

The only crop in this series which can be compared with those of the shorter rotation is the wheat crop, which is practically the same in both, and the clover crop, which is 2,400 pounds for Plot 28 in this case against 2,886 pounds as the average yield of the unfertilized hay in the short rotation for 1896. The yields of Plot 28 run, as a rule, quite close to those of the county, which, as already shown, are reëenforced by large purchases of commercial fertilizers. These yields on Plot 28 are the yields found in the continuous culture of crops in rotation with clover, but without any manure or fertilizer. They must, therefore, be taken as representing the capacity of a soil which has been somewhat reduced in natural fertility. This reduction, however, has been small, as compared with what many of the older fields of Wayne county have suffered, judging by the remaining unfertilized plots in this test.

The first settlements in what is now Wayne county were made during the first decade of the century. Wooster was laid out in 1808; the patents for the lands now occupied by the Experiment Station were issued under President Monroe in 1821, and it is probable that the portion occupied



OATS ON SECTION C, 5-YEAR ROTATION,
as seen from the tower of the main building, half a mile west. Taken in July, 1899.



OATS IN CONTINUOUS CULTURE.
The fifth consecutive crop at Wooster. The plots are numbered from right to left. Taken in July, 1898.

by the longer rotation in these experiments has been in cultivation for at least 50 or 60 years.

The character of this soil, both in physical and chemical constitution and in the natural drainage furnished by the slow decay of the roots of the white oak, with which it was originally covered, rendered it especially adapted to the culture of wheat; and under the careful tillage of the thrifty Pennsylvania-German farmers, who were the original settlers of this region, Wayne county became noted for its wheat production, and the culture of this cereal increased until for many years more than one-seventh of the entire area has been annually sown in wheat.

The Wayne county farmers for many years followed the traditions of their Pennsylvania ancestors, in the keeping of live stock and the use of barnyard manure; but with the depression in live stock values, following the first exploitation of the western ranges, and the coincident introduction of commercial fertilizers, they parted with their cattle and sheep and began the purchase of fertilizers to such an extent that the number of cattle kept in the county fell from 31,000 in 1881 to 20,000 in 1897, and the number of sheep from 50,000 to 22,000, during the same period, while the expenditure for fertilizers has risen to an average of more than $40,000 annually.

During the 20 years, 1850 to 1869, the wheat yield of Wayne county rose from 12½ to 16 bushels per acre. This increase was accomplished under the old system of live stock husbandry. For the three decades since the average yields have been as follows:

1870–79	16.8 bushels per acre.
1880–89	16.9 " " "
1890–99	16.2 " " "

In other words, by a large and increasing expenditure for commercial fertilizers, the present generation of Wayne county farmers are able to maintain their wheat yield at the point to which their fathers brought it by live stock husbandry.

RATIO OF STRAW TO GRAIN.

The complaint is common in Ohio, especially on the rich, clay loams which characterize so large a proportion of the glacial drift, that it is much easier to produce straw than grain, and no question relating to soil management has been asked more earnestly of the Experiment Station than how to overcome this difficulty. It is common to assume that this excessive proportion of straw is due to an excess of available nitrogen in soil or fertilizer, but this does not seem to be a sufficient explanation.

In the experiments of this Station the relative yields of straw and grain have shown great variation in different seasons, the proportion of straw in the total produce being much greater in some seasons than in others, thus showing that climate is an important factor in determining

the average ratio of any locality; but our experiments also show that other factors are also at work, some of which may be controlled by the farmer.

RATIO OF STRAW TO GRAIN IN WHEAT.

In Table XXVII is given the number of pounds of straw required to carry a bushel of wheat in the experiments of this Station, taking the average of all the unfertilized plots in each test, the fertilized plots from No. 2 to No. 12 inclusive, and the plots receiving 8 tons of barnyard manure at a dressing:

It will be seen from this table that in each of these experiments Plot 2, receiving phosphoric acid only, in superphosphate, has required more straw to carry a bushel of grain than the corresponding unfertilized plots, and the same is true of Plot 5, receiving nitrogen only, in dried blood and nitrate of soda. At Wooster and Neapolis the quantity of straw per bushel is greater on Plot 5 than on Plot 2, and at Columbus and Strongsville it is less. Where these two dressings are combined, on Plot 6, the ratio of straw to grain is increased in the first period at Columbus, but in none of the other tests does it rise above that found either on Plot 2 or on Plot 5, while in three of them it falls below either of the plots mentioned. When muriate of potash is added to the nitrogen and phosphoric acid (on Plot 11) the ratio of straw to grain makes a further advance in the Columbus test and remains nearly stationary in the longer of the two rotations at Strongsville, but in all the other tests it falls practically to the level of the unfertilized plots. A further addition of nitrate of soda (on Plot 12) does not materially increase the ratio of straw to grain, and the application of 8 tons of barnyard manure per acre apparently has approximately the same effect on this point as the use of this larger application of the more available form of nitrogen.

The plot receiving muriate of potash alone shows in every test, except the longer rotation at Wooster, a smaller weight of straw to the bushel of grain than is found on the unfertilized plots, and the combination of potash with phosphoric acid or nitrogen, either one without the other, shows generally a smaller quantity of straw per bushel of grain than is found where phosphoric acid is used alone or in combination with nitrogen.

In the case of the continuous cropping at Columbus, during the period when the fertilizer was being applied, and of both the longer rotations, the maximum yield of grain is invariably accompanied by a high yield of straw; but in the shorter rotations the ratio of straw to grain is no greater in case of the largest yields than on the unfertilized plots, and yet the maximum yield is much higher in the short rotations than in the longer ones.

Further light is shed upon this question by Plots 14 and 15 of the shorter rotation. Both these plots are heavily fertilized, receiving in each

TABLE XXVII. RATIO OF STRAW TO GRAIN IN WHEAT EXPERIMENTS.

Plot	Fertilizer	Columbus: First period, 7 crops	Columbus: Second period, 3 crops	Wooster: 5-year rotation, 6 crops	Wooster: 3-year rotation, 5 crops	Strongsville: 5-year rotation, 3 crops	Strongsville: 3-year rotation, 3 crops	Neapolis: 3-year rotation, 4 cr'ps
		Bushels per acre						
	Average unfertilized....	25.21	24.15	9.28	19.59	6.80	9.76	12.03
2	Superphosphate	29.94	28.71	12.19	25.07	13.69	20.64	13.66
3	Muriate of potash......	26.69	24.51	10.80	22.75	6.01	14.97	15.79
5	Nitrate of soda.........	27.09	22.90	11.14	22.23	6.60	11.33	14.96
6	Superphos. and nitrate..	28.42	27.29	16.98	27.60	18.06	25.11	16.33
8	Superphos. and potash..	29.53	30.65	15.18	27.77	14.56	23.89	14.79
9	Potash and nitrate.....	29.38	26.72	11.49	27.15	8.96	11.84	15.46
11	Superphos. potash & nitr	31.29	28.85	20.91	29.74	19.09	26.30	15.96
12	Superphos. potash & nitr	31.87	30.08	21.57	31.12	23.54	25.92	17 19
14	Superphos. potash & nitr	....	....	....	32.07	....	27.28	......
15	Superphos. potash & nitr	....	....	....	30.02	....	23.11	......
	Barnyard manure.......	29.58	30.58	13.18	23.38	17.70	17.06	......
		Pounds of straw per bushel						
	Average unfertilized ...	97	91	105	98	95	93	88
2	Superphosphate	109	98	113	102	114	101	93
3	Muriate of potash......	94	88	112	94	88	89	91
5	Nitrate of soda........	100	93	117	107	97	98	97
6	Superphos. and nitrate..	115	92	117	100	104	90	94
8	Superphos. and potash..	108	93	102	91	98	88	92
9	Potash and nitrate......	106	90	110	91	107	90	86
11	Superphos. potash & nitr	124	100	114	94	96	93	89
12	Superphos. potash & nitr	124	96	116	97	108	96	85
14	Superphos. potash & nitr	....	....	....	95	....	94	......
15	Superphos. potash & nitr	....	....	....	90	....	93	......
	Barnyard manure.......	114	104	125	96	100	92	......

three years' course a total of 1,100 pounds of fertilizing material, against 1,300 pounds, distributed over five years, in the longer rotation. On Plot 14, in the shorter rotation, the fertilizer is divided between the potatoes and wheat, about two-thirds of the whole being given to the potatoes, while on Plot 15 the entire quantity is given to the potatoes. The result is a 5-year average on Plot 14 of 32 bushels of wheat per acre at Wooster and a 3-year average of 27 bushels at Strongsville, this being the maximum yields in the two experiments, and attained with a relatively low ratio of straw to grain.

THE RATIO OF STRAW TO GRAIN IN OATS.

Table XXVIII gives for the oats crops similar data to those previously given for wheat. It appears from this table that superphosphate

TABLE XXVIII. RATIO OF STRAW TO GRAIN IN OATS EXPERIMENTS

Plot	Fertilizers	Columbus First period	Columbus Second period	Wooster	Str'gsville
	Bushels per acre				
	Average unfertilized	34.84	26.81	30.91	32.87
2	Superphosphate	....	26.32	39.07	41.97
3	Muriate of potash	38.30	....	34.71	33.77
5	Nitrate of soda	37.16	31.37	36.25	31.72
6	Superphosphate and nitrate	38.34	36.00	42.41	44.94
8	Superphosphate and potash	35.62	29.91	40.11	43.51
9	Potash and nitrate	39.52	34.50	34.13	36.20
11	Superphosphate, potash and nitrate	42.66	34.76	46.10	48.41
12	Superphosphate, potash and nitrate	42.60	38.42	47.27	49.93
14	Superphosphate, potash and nitrate	40.74	37.06	*37.85	*40.90
	Superphosphate, potash and sulph. ammonia	40.78	35.87	45.68	48.96
	Barnyard manure	35.98	35.92	*38.31	*39.20
	Pounds of straw per bushel				
	Average unfertilized	71	54	39	39
2	Superphosphate	....	57	35	39
3	Muriate of potash	71	....	36	37
5	Nitrate of soda	74	61	36	39
6	Superphosphate and nitrate	71	57	37	36
8	Superphosphate and potash	76	53	37	37
9	Potash and nitrate	72	60	35	40
11	Superphosphate, potash and nitrate	69	68	40	41
12	Superphosphate, potash and nitrate	72	70	42	41
14	Superphosphate, potash and nitrate	72	78	40	39
	Superphosphate, potash and sulph. ammonia	70	66	41	46
	Barnyard manure	74	67	38	37

* Fertilizers and manure applied to the corn crop; oats following, unfertilized.

used alone, has had a similar effect at Columbus in increasing the relative weight of straw in oats to that observed in wheat, while it has failed to produce any increase in the weight of grain; at Wooster and Strongsville, however, it has had the opposite effect, producing a marked increase of grain without increasing the ratio of straw. In fact a decrease in this ratio is shown at Wooster. Muriate of potash and nitrate of soda used separately have apparently produced an actual, though small, increase of crop at Columbus and Wooster, with negative results at Strongsville. They seem not to have materially affected the ratio of straw. A decided increase of crop in all the tests is shown by the combination of superphosphate and nitrate of soda, on Plot 6, and this is accomplished not only without increase, but with a small reduction in the relative weight of straw. When muriate of potash is added to the dressing, on Plot 11, there is a further increase of crop, in which the straw seems to take the

TABLE XXIX. RATIO OF STOVER TO EAR-CORN IN CORN EXPERIMENTS.

Plot	Fertilizers	Columbus First period, 5 crops	Columbus Second period, 6 crops	Wooster 5-year rotation, 6 crops	Strg'sville 5-year rotation, 4 crops
	Bushels per acre				
	Average unfertilized	64.27	33.76	31.89	27.90
2	Superphosphate	63.98	34.54	36.02	30.30
3	Muriate of potash	65.42	40.39	34.93	25.93
5	Nitrate of soda	70.50	41.51	35.38	24.11
6	Superphosphate and nitrate	71.86	39.69	43.32	29.66
8	Superphosphate and potash	65.96	41.20	40.11	27.79
9	Potash and nitrate	71.80	41.10	33.00	25.75
11	Superphosphate, potash and nitrate	70.56	41.94	41.28	37.43
12	Superphosphate, potash and nitrate	72.14	41.23	41.07	36.23
	Barnyard manure	67.68	36.59	40.73	38.68
	Pounds of stover per bushel				
	Average unfertilized	61	50	51	55
2	Superphosphate	59	50	45	45
3	Muriate of potash	68	51	49	49
5	Nitrate of soda	69	51	47	53
6	Superphosphate and nitrate	65	53	42	45
8	Superphosphate and potash	68	56	46	43
9	Potash and nitrate	67	50	50	51
11	Superphosphate, potash and nitrate	64	56	44	44
12	Superphosphate, potash and nitrate	63	52	44	46
	Barnyard manure	59	51	50	47

lead, and this tendency is more definitely shown on Plot 12, with an increase of nitrate of soda in the dressing. When we reach Plot 14, in the work at Wooster and Strongsville, on which the fertilizers are applied only to the wheat and corn, there is a considerable reduction in the yield per acre, although it still remains well above the unfertilized yield, while the relative yield of straw remains practically the same as on the unfertilized plots. On the plots where barnyard manure is used on the preceding crops the relative yield of straw falls below that on the unfertilized plots.

RATIO OF STOVER TO EAR-CORN.

In Table XXIX the ratio of stover to ear-corn is compared, as found in the two periods of the continuous cropping at Columbus, and in the rotative cropping at Wooster and Strongsville. From this table it will be seen that in the experiment in continuous culture at Columbus the general tendency of the fertilizers has been with corn, as with wheat and oats, to increase the total weight of plant more rapidly than that of grain; the only exceptions to this tendency in corn being found in the

case of superphosphate, used alone, and of barnyard manure. The superphosphate, however, in this case as on oats, fails to produce any increase of crop at Columbus, contrary to its action on wheat, and quite contrary to its action at Wooster and Strongsville. The probable explanation of this fact has already been given (pp. 40, 42).

At Wooster and Strongsville the fertilizers and manure appear to cause in every case a larger increase of grain than of stover.

RATIO OF STRAW AND STOVER TO GRAIN AS AFFECTED BY CONTINUOUS CROPPING.

It will have been observed that the ratio of straw and stover to grain is constantly larger at Columbus than in the more northerly tests. That this difference is not altogether due to the effect of continuous, as compared with rotative cropping, is shown by Table XXX, in which are given the results of the experiments with corn, wheat and oats, grown in continuous culture at Wooster, which show that the ratio of straw and stover to grain in this continuous cropping is as yet not higher than in the rotative cropping on the same land (See Tables XXVII, XXVIII and XXIX), it being remembered that the soil on which these tests are located is of the same character and has had the same previous history as that carrying the experiment in which the same crops are grown in rotation. Here we find that the light dressings of barnyard manure produce a uniform increase in both grain and straw, in the case of oats, and a larger increase of grain than of stover in the case of corn. The dressings of chemical fertilizers, on Plots 3 and 9, which approximate the composition of the plant (and also that of the manure) produce a larger increase of wheat and oats than the manure, but practically the same increase of corn, and in this increase the grain bears a relatively smaller proportion in wheat and corn. When this dressing is reënforced by additional quantities of superphosphate and muriate of potash, on Plots 2 and 8, there is a further increase of crop, in which the straw shows the larger gain in wheat and oats, but in corn the relative gain still remains approximately uniform. When we compare the plots receiving 160 pounds of nitrate of soda with those receiving 320 pounds, we find that the larger dressing of nitrate has apparently caused a large increase of straw in the case of wheat and oats, while the corn crop shows comparatively little effect, either in grain or straw.

It will be observed that in these tests the banryard manure has been more effective on corn than on oats or wheat, while the chemical fertilizers have shown greater effect on the oats and wheat. The response of the oats to the increase of nitrogen in the fertilizer is especially noteworthy, the 6-year average yield of 51 bushels per acre on plot 8 being the maximum yield thus far attained over so long a period in these tests.

Another difference between the habit of corn on the one hand, and

TABLE XXX.—RATIO OF STRAW OR STOVER TO GRAIN IN CROPS GROWN IN CONTINUOUS CULTURE AT WOOSTER.

Plot	Fertilizers per acre	Wheat		Oats		Corn	
		Bushels per acre	Pounds of straw per bush'l	Bushels per acre	Pounds of straw per bush'l	Bushels per acre	Lbs of Stover per bu.
	Average of unfertilized plots.....	9.01	113	28.00	36	26.26	51
5	Barnyard manure, 2½ tons......	12.39	112	31.00	36	36.44	46
6	Barnyard manure, 5 tons........	14.95	113	35.78	36	43.13	45
3	160 pounds nitrate of soda.... One-third ration superphos. and potash*	15.39	106	39.74	37	38.86	46
8	320 pounds nitrate of soda.... Two-thirds ration superphos. and potash*	18.64	107	49.11	42	42.76	44
2	160 pounds nitrate of soda.... 160 pounds superphosphate.... 100 pounds muriate of potash.	19.58	112	42.89	40	44.61	47
8	320 pounds nitrate of soda.... 160 pounds superphosphate.... 100 pounds muriate of potash..	21.01	119	51.30	43	44.43	45

*Approximately.

wheat and oats on the other, is shown in these tests in the general tendency of fertilizers and manure to increase the yield of straw, rather than grain, in the case of oats and wheat, while the opposite effect is generally observed in the case of corn.

Taken as a whole, these experiments would seem to justify the conclusion that in wheat and oats the normal balance between straw and grain may not always be found in the least proportion of straw in the entire plant, as such a condition may be but a manifestation of the phenomenon observed in many cases, in which a threatened impairment of vitality may abnormally stimulate the reproductive forces; but that this balance may be disturbed by the presence in the soil of a superabundance of one or more of the essential constituents of plant food, or by a deficiency of such constituents, or by unfavorable climatic conditions.

The experiments indicate that it is possible to increase the yield of grain to a high point without unduly increasing the weight of straw, and suggest that this may be accomplished by the culture of the cereals in systematic rotation with clover or other leguminous crops and with such cultivated crops as potatoes, roots or corn, crops which will bear liberal fertilizing, the fertilizers or manures to be applied largely to these crops rather than exclusively to the small grains.

One of the most obvious suggestions which these tests seem to offer is that the most effective system of maintaining fertility in such a rotation as the longer one employed in these experiments would be found in applying barnyard manure to the corn crop and following with moderate

dressings of chemical fertilizers on the oats and wheat. Such a system would permit the hauling of the barnyard manure direct from the stable to the field during the winter, thus not only economizing in labor but saving much of the loss which manure suffers on the average Ohio farm, by heating in neglected heaps in the barnyard.

EXPERIMENTS WITH BARNYARD MANURE.

The barnyard manure employed in the general experiments of this Station has purposely been treated according to the custom generally followed in Ohio; that is, as fast as accumulated during the winter it has been thrown into open yards, where it has been subjected to more or less trampling by stock, and has taken the rain for several months, before being spread upon the field.

The results obtained from this method of management, while such as to abundantly justify the making and use of manure, even in this loose manner, in preference to the purchase of chemical fertilizers, have nevertheless seemed to us considerably below what ought to be obtained. In the spring of 1897, therefore, an experiment was instituted on the following plan:

1. In cleaning out the cow stables certain portions of manure, taken from uniformly fed animals, are piled separately and dusted with one of the following materials, applying as nearly as possible two pounds of the material to every hundred pounds of manure:

(a) Finely ground, untreated phosphate rock (floats); (b) the same rock acidulated (acid phosphate); (c) kainit; (d) gypsum.

It is planned that the manure thus treated shall be subjected to the ordinary winter management of open-yard manure until plowing for corn begins in April, when it is spread upon permanent plots on a section of the East Farm.

2. About a week before time to begin plowing, manure is taken from box stalls, in which it has been trampled under foot while accumulating, without exposure to rain, and is divided into separate heaps and dusted with the materials named above, using the same proportions. This manure, after standing a few days, is spread upon duplicate plots, according to the plan accompanying. At the same time similar quantities of untreated manure are taken from the yard and from the box stall and spread upon other plots, and the whole is then plowed under to a shallow depth and prepared for planting.* Before planting two plots are dressed with commercial fertilizers, duplicating the applications given to Plots 11 and 30 in the 5-year rotation previously described.

The corn is followed by wheat without further manuring or fertilizing, and the wheat is to be followed by clover. Thus far, however, the

*For the crop of 1899 the manure was all spread after plowing.

TABLE XXXI: EXPERIMENTS WITH BARNYARD MANURE.

Yield and increase in pounds per acre.

Plot	Manures and fertilizers	Corn, (3 crops)				Wheat, (2 crops)			
		Yield		Increase		Yield		Increase	
		Ear-corn	Stov'r	Ear-corn	Stov'r	Grain	Straw	Grain	Straw
1	Unmanured	2,817	1,569	......	......	702	1,169	......	......
2	Yard manure and floats.	3,763	2,213	1,058	697	1,186	2,037	509	933
3	Stall manure and floats.	3,868	2,271	1,275	808	1,322	2,237	671	1,198
4	Unmanured	2,481	1,411	......	......	626	974	......	......
5	Yard manure and acid phosphate	3,520	1,998	1,121	648	1,186	1,965	560	978
6	Stall manure and acid phosphate	3,685	2,095	1,368	806	1,306	2,213	680	1,213
7	Unmanured	2,235	1,227	......	......	626	1,013	......	......
8	Yard manure and kainit.	3,429	1,873	1,089	565	1,182	2,081	520	1,053
9	Stall manure and kainit.	3,695	2,013	1,249	624	1,250	2,213	552	1,170
10	Unmanured	2,551	1,470	......	......	734	1,058	......	......
11	Unmanured	2,743	1,629	......	......	794	1,309	......	......
12	Yard manure & gypsum	3,800	2,299	1,090	711	1,178	2,077	460	902
13	Stall manure & gypsum	4,056	2,521	1,377	973	1,250	2,029	608	989
14	Unmanured	2,647	1,507	......	......	565	905	......	......
15	Yard manure alone.....	3,625	2,073	989	557	966	1,721	408	816
16	Stall manure alone.....	3,695	2,188	1,070	664	906	1,621	356	716
17	Unmanured	2,614	1,532	......	......	542	905	......	......
18	Chemical fertilizer A[1]..	3,096	1,815	463	308	718	1,281	154	301
19	Chemical fertilizer B[2]..	3,156	1,736	504	254	826	1,285	241	230
20	Unmanured	2,670	1,455	......	......	606	1,129	......	......
	Average unfertilized yield	2,595	1,471	......	......	649	1,058	......	......
	Average yield from yard manure	3,627	2,091	1,070	636	1,139	1,976	491	936
	Average yield from stall manure	3,800	2,218	1,268	775	1,207	2,063	572	1,057

[1] Chemical fertilizer A:—
Acid phosphate, 80 lbs. per acre
Muriate of potash, 80 " "
Nitrate of soda, 160 " "

[2] Chemical Fertilizer B:—
Acid phosphate, 100 lbs. per acre
Tankage, 100 " "
Muriate of potash, 10 " "

clover seeding has failed and soy beans have been grown instead, and the bean crop has been plowed under.

The object of this experiment, it will be seen, is to compare open-yard with covered-yard manure, and to test the effect, as preservatives or reënforcements, of the materials added to the manure.

The land on which the test is located was in oats in 1892; in 1893 it was plotted and drained and sown to wheat. In 1895 and 1896 it was in clover and timothy. No manure has been used upon it since it came into possession of the Station, until the beginning of this test. Table XXXI gives the results of the test to date.

The table shows that the stall manure has, in every instance, produced a larger total increase in the two crops than the yard manure, and

that the manures treated with either floats, acid phosphate, kainit or gypsum, have regularly produced a larger increase than those not so treated.

The average difference in favor of the stall manures amounts to 198 pounds of ear corn, 139 pounds of stover, 81 pounds of wheat and 121 pounds of straw per acre, the whole worth $2.21 per acre, at the low valuations previously employed, or 27 cents per ton of manure.

The average increase from the treated manures over those untreated amounts to $2.72 per acre, or 34 cents per ton of manure, by the same valuation, a difference amply sufficient to justify the use of any of the materials employed, at ordinary prices. In both crops the stall manure shows a decidedly larger gain from treatment than the yard manures; this point is shown in Table XXXII, which gives the excess in increase from each treated manure over the same description of manure untreated:

TABLE XXXII: EXCESS IN INCREASE FROM TREATED MANURES OVER UNTREATED.

Plot	Treatment	Excess in pounds per acre			
		Corn		Wheat	
		Ear-corn	Stover	Grain	Straw
2	Yard manure and floats	69	140	101	117
3	Stall manure and floats	205	144	315	382
5	Yard manure and acid phosphate	132	91	152	162
6	Stall manure and acid phosphate	298	142	324	497
8	Yard manure and kainit	100	8	112	237
9	Stall manure and kainit	179	40	196	454
12	Yard manure and gypsum	101	154	52	86
13	Stall manure and gypsum	307	309	252	273

The stall manure used in these tests has thus far been taken from bulls, these being the only animals kept constantly confined, and they have been fed on a maintainence ration only, whereas the cows furnishing the yard manure have been liberally fed for milk production; moreover, the yard manure has been exposed for but a few months at most, and in a level yard, subject neither to wash from eaves nor to that from higher ground. Its condition is very different from that of manure which has lain in a barnyard throughout a summer. It is believed, therefore, that the test shows only a part of the actual difference between what is actually realized from stable manure under average management and what might be realized.

The retail cost of the 40 pounds of material used for dusting a ton of manure has been about 20 cents for the floats, 30 cents for the acid phosphate, 36 cents for the kainit and 15 cents for the gypsum. The value of the average increase found in the corn and wheat crops thus far grown on Plot 15, receiving untreated yard manure, amounts to $11.08 per acre, or $1.38 per ton of manure. The value on Plot 16 is no greater, owing to the slightly lower yield of the more valuable wheat crop; but on all the other plots the stall manure gives a decidedly larger return than the yard manure, as shown in Table XXXIII, which gives the financial aspect of this experiment. The last two columns of this table give the net value of the increase per ton of manure, after deducting the cost of the material added.

TABLE XXXIII: GAIN FROM TREATMENT OF MANURE.

Material added	Value of increase per acre		Net value of increase per ton of manure	
	From yard manure	From stall manure	Yard	Stall
Nothing	$11.08	$10.97	$1.38	$1.37
Floats	12.87	16.17	1.31	1.82
Acid phosphate	13.71	16.74	1.41	1.79
Kainit	13.06	14.42	1.27	1.44
Gypsum	12.48	16.02	1.41	1.90

While this test has not yet been carried far enough to justify final conclusions, the results certainly lend encouragement to the belief that it is possible to realize a great deal more from barnyard manure than is now done in average farm practice.

It appears, at this stage of the experiment, that the chief value of the materials added lies in their arrest of escaping ammonia, rather than in actual plant food added.

THE RECOVERY OF FERTILIZING CONSTITUENTS.

In Table XXXIV is given the average percentages of water, potash and nitrogen found in the crops employed in these experiments, as determined by American analyses. From these analyses Table XXXV has been compiled, in which is shown the total quantity of phosphoric acid, potash and nitrogen applied during the course of the 5-year rotation in our experiments, the estimated number of pounds of each recovered in the combined average increase at Wooster and Strongsville, and the percentage which this recovery bears to the quantity applied in the fertilizer.

TABLE XXXIV. FERTILIZING CONSTITUENTS IN FARM CROPS[1]

Crops	Water	Phosphoric acid	Potash	Nitrogen
Corn (dent): — grain	10.6	.70	.40	[2]1.60
stover	10.2	.23	.99	[2]1.02
cobs	[3]7.9	[3].06	[3].60	[3].50
Oats: — grain	11.0	.89	.67	1.89
straw	9.2	.22	1.21	.64
Wheat (winter): — grain	10.5	.93	.64	[4]2.22
straw	9.6	.09	.72	.50
Clover hay	15.3	.36	2.10	1.98
Timothy hay	13.6	.33	1.42	.94
Potatoes	79.1	.12	.45	.34

[1] The analyses in this table are those published in the Annual Report of the New Jersey Experiment Station for 1896, except where otherwise noted.

[2] Analyses of this Station.

[3] Analyses of Massachusetts State Experiment Station.

[4] Average of 334 samples of Ohio wheat, including many differently named sorts, analyzed by this Station.

TABLE XXXV. FERTILIZING CONSTITUENTS APPLIED AND RECOVERED IN INCREASE IN ROTATIVE CROPPING

Plot	Pounds applied per acre			Pounds recovered per acre			Per cent. recovered		
	Phosphoric acid	Potash	Nitrogen	Phosphoric acid	Potash	Nitrogen	Phosphoric acid	Potash	Nitrogen
2	50.	......	......	10.15	24.64	29.79	20.	......	......
3	....	130	......	3.37	9.52	10.94	....	7.3	......
5	....	......	75	3.75	11.04	12.49	....	......	17
6	50.	......	75	18.78	48.21	57.37	38.	......	76
8	50.	130	......	13.74	34.55	41.47	27.5	27	......
9	....	130	75	4.88	15.29	16.02	....	12	21
11	50.	130	75	23.80	60.39	72.30	48.	46	96
12	50.	130	112	23 00	56.64	68.70	46.	44	61
14	37.5	90	50	18.88	50.77	59.87	50.	57	120
15	25.	65	25	12.48	25.65	34.69	50.	39	139
20	50.	10	12	17.47	49.24	55.55	35.	......	......

From this table it appears that when phosphoric acid has been applied alone, in superphosphate, 20 per cent. of the quantity applied in the fertilizer has been recovered in the increase of crop. When phosphoric acid has been reënforced with potash, there has been a recovery of 27 per cent. of the former. When phosphoric acid has been reënforced with nitrogen instead of potash the recovery has reached 38 per cent. of the phosphoric acid applied, and when both potash and nitrogen have been added the recovery of the phosphoric acid has amounted to 46 to 50 per cent.

When potash has been used alone, in the muriate, but 7 per cent. of that applied in the fertilizer has been recovered in the increase of crop. When it has been reënforced with nitrogen there has been a recovery of 12 per cent.; when phosphoric acid has been added instead of nitrogen, 27 per cent. of the potash has been recovered, and when both nitrogen and phosphoric acid were added, the recovery of potash has run from 44 to 57 per cent.

When nitrogen has been added alone, in nitrate of soda and a combination of nitrate of soda and dried blood, 17 per cent. of the nitrogen applied in the fertilizer is found in the increase; when the nitrogen is reënforced with potash, 21 per cent. of the nitrogen is recovered; when phosphoric acid is added instead of potash the recovery of nitrogen reaches 76 per cent., and when both phosphoric acid and potash are added, the total recovery of nitrogen has amounted to 96 per cent. of that applied in the fertilizer on Plot 11, and has considerably exceeded that proportion on Plots 14 and 15. It would seem, therefore, that the clover grown in this rotation is furnishing some excess of nitrogen, which the succeeding crops are able to utilize, when they are grown under conditions of relatively deficient nitrogen supply; but it is notable that the phosphoric acid and potash found in the increase never much exceed half that given in the fertilizer, however abundant the nitrogen supply may be. These points are graphically brought out by Diagram VIII, which shows that there has been an approximately uniform recovery of phosphoric acid and potash, with reference to each other, this recovery exceeding half the quantity applied in the fertilizer on one plot only, while there has been a very much higher proportionate recovery of nitrogen. The diagram also shows well the superior effectiveness of combination; the addition of an abundant supply of nitrogen nearly doubles the effectiveness of the pound of phosphoric acid (compare Plots 2 and 6) and the presence of an abundant supply of phosphoric acid more than quadruples the effectiveness of the pound of nitrogen (Plots 5 and 6); and when both phosphoric acid and potash are present in ample quantity, the effectiveness of the nitrogen is still further increased.

Further light is thrown on this point by the experiment in continuous culture, which is being carried on at Wooster parallel to the rotative cropping. In this experiment Plots 2 and 8 are fertilized similarly to Plots 11 and 12 in the rotation, the different fertilizing constituents being given in

DIAGRAM VIII. FERTILIZING CONSTITUENTS APPLIED PER ACRE IN FIVE-YEAR ROTATION AND PERCENTAGE RECOVERED IN INCREASE OF CROP.

Average of nine rotations.

Plot	Fertilizing constituents applied in 5 years: Phosphoric acid	Potash	Nitrogen
2	50	....	....
3	....	130	....
5	....	....	75
6	50	....	75
8	50	130	....
9	....	130	75
11	50	130	75
12	50	130	112
14	37.5	90	50
15	25	65	25
30	50	10	12

Percentage of phosphoric acid, potash and nitrogen in increase of crop on quantities applied in fertilizers

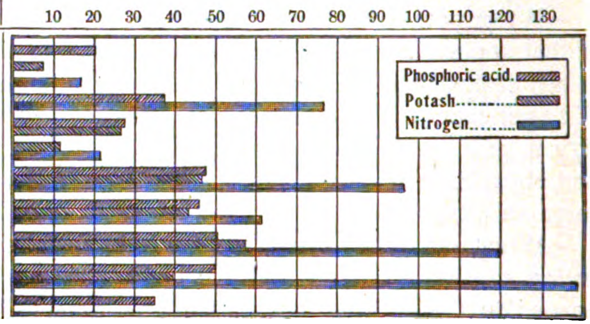


TABLE XXXVI. FERTILIZING CONSTITUENTS APPLIED PER ACRE AND RECOVERED IN INCREASE IN CONTINUOUS CROPPING.

Six-year average.

Crop	Plot No	Pounds applied: Phosphoric Acid	Pounds applied: Potash	Pounds applied: Nitrogen	Pounds recovered: Phosphoric Acid	Pounds recovered: Potash	Pounds recovered: Nitrogen	Percent recovered: Phosphoric Acid	Percent recovered: Potash	Percent recovered: Nitrogen
Corn ...	2	25.	50.	25.	8.08	11.33	22.67	32.3	22.7	90.7
	8	25.	50.	50.	10.50	14.27	28.94	42.0	28.5	57.9
	3	9.4	15.	25.	5.20	6.89	14.24	55.3	46.0	57.0
	9	18.8	30.	50.	10.13	13.81	27.65	53.9	46.0	55.3
Oats ...	2	19.5	50.	25.	6.26	13.02	14.67	25.0	26.0	58.7
	8	25.	50.	50.	8.92	18.28	20.86	35.7	36.6	41.7
	3	8.6	25.	25.	4.55	9.55	10.53	52.9	38.2	42.1
	9	17.2	50.	50.	7.91	16.16	18.48	46.0	32.3	37.0
Wheat .	2	25.	50.	25.	6.73	11.76	19.16	26.9	23.5	76.6
	8	25.	50.	50.	8.13	15.57	23.72	32.5	31.1	47.4
	3	7.	15.	25.	4.03	6.78	11.37	57.6	45.2	45.5
	9	14.	30.	50.	6.48	11.72	18.62	46.3	39.1	37.2

arbitrary quantities, while on Plots 3 and 9 the nitrogen remains the same, but the phosphoric acid and potash are reduced to quantities bearing approximately the same ratio to the nitrogen carried by 160 pounds or 320 pounds of nitrate of soda, as is indicated by the average analyses of the crops.

The general results of this test are given in Table XXXVI, which shows that when the three fertilizing constituents have been given in their theoretical ratio to each other (Plots 3 and 9) their recovery has varied within comparatively narrow limits, but in no case does the realization of the phosphoric acid or potash, nor the average of the three constituents, reach sixty per cent. of the amount applied.

When the relative quantities of phosphoric acid and potash are increased, on Plots 2 and 8, there is a considerable gain in the increase of crop, but this gain is made at a loss in average utilization of the fertilizing constituents, except the nitrogen, which shows a considerable increase. It will be observed that the average recovery, especially of nitrogen, is greater throughout in the case of the corn crop than of either oats or wheat, which is in harmony with general observation and experience on this point. It appears that the nitrogen of the nitrate of soda is relatively more available than the potash of the muriate, or the phosphoric acid of superphosphate (acid phosphate in this case), but in no case in this experiment of continuous cereal culture is all the nitrogen recovered, even from this, perhaps the most satisfactory in this respect of all commercial fertilizing materials.

The practical application of this study of the recovery of fertilizing constituents is to be found in a comparison of the cost of fertilizing materials with the value of the increase of crop produced by them.

A bushel of corn, with its cobs and stover, contains on the average about half a pound of phosphoric acid, three-fourths of a pound of potash and a pound and a half of nitrogen. Farmers who purchase mixed fertilizers from the retail dealers are paying in Ohio from 5 to 6 cents per pound for available phosphoric acid, from 6 to 8 cents for potash, and from 20 cents upward for nitrogen. At the lowest of these prices the phosphoric acid, potash and nitrogen found in a bushel of corn, with its cobs and stover, would cost 37 cents, or more than the corn is worth in the average market; but our experiments in continuous culture show that we would have to apply in the fertilizer at least twice as much phosphoric acid and potash, and from 10 to 80 per cent. more nitrogen than is found in the increase of crop, in attempting to produce corn by the aid of commercial fertilizers alone. This point may perhaps best be illustrated by Table XXXVII, in which is given the value of the increase and the cost of the fertilizing materials used to produce it in the experiments on crops grown in continuous culture.

TABLE XXXVII. COST OF PRODUCING CROPS BY CHEMICAL FERTILIZERS ALONE.

Plot	Cost of fertilizers				Value of increase	Loss
	Phosphoric acid	Potash	Nitrogen	Total		
Corn.						
2	$1.25	$3.00	$5.00	$9.25	$6.76	$2.49
8	1.25	3.00	10.00	14.25	8.82	5.43
3	.47	.90	5.00	6.37	4.36	2.01
9	.94	1.80	10.00	12.74	8,53	4.21
Oats.						
2	1.25	3.00	5.00	9.25	4.85	4.40
8	1.25	3.00	10.00	14.25	6.94	7.31
3	.43	1.50	5.00	6.93	3.60	3.33
9	.86	3.00	10.00	13.86	6.16	7.70
Wheat.						
2	1.25	3.00	5.00	9.25	7.90	1.35
8	1.25	3.00	10.00	14.25	9.53	4.72
3	.35	.90	5.00	6.25	4.73	1.52
9	.70	1.80	10.00	12.50	7.59	4.91

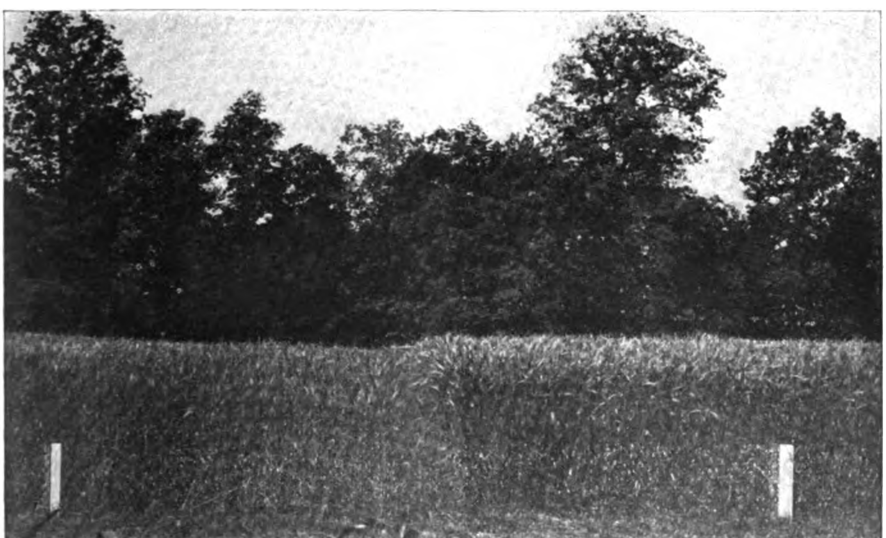
It will be observed that the nitrogen is the chief factor of cost in the above estimates, and the question naturally arises, is it necessary to give so much nitrogen? The answer to this question is given in Table XXXVIII, which shows the total quantity of phosphoric acid, potash and nitrogen applied to each plot, the ratio which the nitrogen bears to the phosphoric acid and potash combined, the total quantity of these essential constituents recovered in the increase of crop, and the number of pounds recovered for each hundred pounds in the fertilizer.

Comparing Plots 2 and 8, we see that the increase in the ratio of nitrogen in the fertilizer has increased the proportionate recovery of essential constituents, as shown by the last column of the table, in the case of corn and oats, and has maintained the ratio of recovery in the case of wheat, in the face of the general tendency to decrease in proportionate effectiveness with increase in total quantity of fertilizer. This last tendency probably accounts for the diminished effectiveness of the dressing on Plot 9, as compared with that on Plot 3, their dressings differing only in quantity, not in relative composition. That this, however, is not a sufficient explanation for the superior effectiveness of the application to Plot 3, is shown by the superiority of Plot 9 over Plot 2, although both receive practically the same total quantity of fertilizers.

The above result may be exhibited in another form in the following

PLOT 7. PLOT 6.

Wheat in continuous culture on the farm of the State University, Columbus. Taken just before heading out.



PLOT 28. PLOT 27.

Wheat in 5-year rotation at Wooster, Section B. These views show that the effect of the fertilizer extends to the outside row of the plot to which it is applied, and stops there.

TABLE XXXVIII. RECOVERY OF FERTILIZING CONSTITUENTS UNDER DIFFERENT RATIOS OF NITROGEN IN THE FERTILIZER.

Plot	Pounds of essential constituents in fertilizer	Ratio of nitrogen to phosphoric acid and potash	Pounds of essential constituents recovered	Constituents recovered per 100 pounds in fertilizer
Corn.				
2	100	1:3	42.08	42
8	125.	2:3	53.71	43
3	49.4	3:3	26.38	53
9	98.8	3:3	51.59	52
Oats.				
2	100	1:3	33.95	34
8	125	2:3	48.06	38
3	58.6	3:3	24.63	40
9	117.2	3:3	42.55	36
Wheat.				
2	100	1:3	37.65	38
8	125	2:3	47.42	38
3	47	3:3	22.18	47
9	94	3:3	36.82	39

statement, which gives the value of the increase from 100 pounds of essential constituents in the fertilizer in these different combinations:

Value of increase from 100 pounds of essential constituents in fertilizer.

Plot	Corn	Oats	Wheat
2	$6.76	$4.85	$7.90
8	7.05	5.55	7.62
3	8.83	6.14	10.01
9	8.64	5.26	8.08

In short, in these experiments in continuous culture, the largest effect has been regularly produced when the three chief fertilizing constituents have been employed in approximately the same ratio to each other which they bear in the crops to which they are applied, as on Plots 3 and 9; but such a ratio involves the use of the costliest of the three, nitrogen, in such large proportion as to raise the cost of the increase produced to a point equal to or beyond its value in the market. It is true that the cost of the fertilizer may be reduced by from 20 to 50 per cent., and its efficiency may at the same time be increased, by purchasing such materials as those used in these experiments, rather than those found in the ordinary fertilizer compound; but even then the fact remains, that a considerable portion of the nitrogen required may be produced far more

cheaply by the growing of clover and other leguminous crops, than by purchasing it in any artificial carrier.

In these experiments there has been an average increase over the 6 years in the oat crop, running from 387 pounds, or more than 12 bushels per acre on Plot 3, to 729 pounds, or nearly 23 bushels per acre on Plot 9. The wheat crop has been increased by an average of 375 pounds, or 6¼ bushels per acre on Plot 3, to 728 pounds, or more than 12 bushels per acre on Plot 8. The corn crop has been increased by an average of 692 pounds of ear-corn, or nearly 10 bushels per acre on Plot 3, to 1,418 pounds, or more than 20 bushels on Plot 8. These are high rates of increase, and they show that the failure to produce crops profitably, on purchased plant food solely, is not due to lack of response in the crops themselves.

RECOVERY OF CONSTITUENTS FROM BARNYARD MANURE.

On the basis of average analyses, the barnyard manure used on Plots 5 and 6 in the experiments in continuous culture should contain nitrogen equivalent to that found in 160 pounds and 320 pounds of nitrate of soda, with phosphoric acid and potash in quantities lying between those applied to Plots 3 and 9 on the one hand, and Plots 2 and 8 on the other. The results of the experiment indicate a considerably lower availability for these fertilizing constituents, as found in manure, than in the chemicals employed on the other plots, but they offer a useful suggestion as to the relative ability of the different crops to utilize the plant food in manure, as shown by Tables XXXIX and XL:

TABLE XXXIX. COMPARATIVE RECOVERY FROM BARNYARD MANURE.

Crop	Plot	Pounds of manure	Pounds of increase		Pounds recovered		
			Grain	Straw	Phosphoric Acid	Potash	Nitrogen
Oats	5	5,000	88	20	.74	.35	1.54
	6	10,000	242	252	2.71	4.66	6.19
Wheat	5	5,000	200	428	2.25	4.35	6.58
	6	10,000	357	726	3.97	7.51	11.56
Corn	5	5,000	631	282	4.25	5.57	11.58
	6	10,000	1,172	590	8.04	11.00	17.60

It will be observed that the wheat has recovered more than twice as much plant food from the manure as the oats, and the corn more than three times as much. This matter may be illustrated from the financial side by Table XL, which gives the value of the average increase from manure applied in different quantities to different crops and rotations of crops in the experiments at Wooster:

TABLE XL. VALUE OF INCREASE FROM BARNYARD MANURE.

Plot	Experiment	Manure per acre	Value of increase	
			Total	Per ton of manure
5	Continuous culture — Oats	2½ tons	$0.68	$0.27
6	" " "	5 "	2.19	44
5	" " Wheat	2½ "	2.63	1.05
6	" " "	5 "	4.65	93
5	" " Corn	2½ "	3.46	1.38
6	" " "	5 "	6.65	1.13
20	5-year rotation manured on corn and wheat	8 "	11.92	1.49
18	" " "	16 "	17.83	1.11
17	3-year rotation manured on wheat	4 "	8.35	2.14
18	" " "	8 "	12.90	1.61
30	" " " potatoes	8 "	20.17	2.27

This table shows a steadily increasing financial return with crops grown continuously, from oats to wheat and from wheat to corn; it shows a slightly better return from the manure used in the long rotation than the best outcome from continuous cropping, and a still further increase in value of product in the shorter rotation, especially where the manure is applied to the potato crop. In every case, except in the oat crop, there is a somewhat higher return from a ton of manure in the smaller dressings than in the larger, but in most cases the increased gross return from the larger applications is sufficient to justify their use.

This greater relative productiveness of the smaller applications, especially as between the very small applications of 2½ tons and 5 tons per acre, would probably not have been realized except for the fine pulverization and uniform distribution of the manure given by the spreading machine, and it will be realized at once that this factor must add to the productiveness of the manure, whatever the quantity applied.

CARRIERS OF NITROGEN.

Plots 11, 21, 23 and 24 in the rotation experiments receive continuously the same quantities each of phosphoric acid, potash and nitrogen, the latter being given in nitrate of soda on Plot 11*, linseed oil-meal on Plot 21, dried blood on Plot 23 and sulphate of ammonia on Plot 24. Phosphoric acid was given in dissolved bone-black previous to 1897, and in acid phosphate since, and potash is given in the muriate, allowance being made on Plots 21 and 23 for the phosphoric acid and potash in the

* By referring to the plans of these experiments pp 18 and 21, it will be seen that in all our tests nitrate of soda is given to wheat in combination with dried blood, about one-fourth the total nitrogen ration being given in dried blood in the Fall and the remainder in nitrate of soda in April.

TABLE XLI—VALUE OF AVERAGE INCREASE FROM DIFFERENT CARRIERS OF NITROGEN.

Crop	Culture	Number of crops gr'wn	Carriers of nitrogen: Nitrate of soda, Average value of increase	Nitrate of soda, Rank	Linseed oil-meal, Average value of increase	Linseed oil-meal, Rank	Dried blood, Average value of increase	Dried blood, Rank	Sulphate of ammonia, Average value of increase	Sulphate of ammonia, Rank
Corn ..	5-year rotation Wooster....	5	$4.24	1	$2.94	4	$3.10	3	$3.95	2
	5-year rotation Strongsville	4	3.75	1	2.71	2	1.98	4	2.16	3
	Continuous Columbus ..	11	2.80	1	.....	......	......	......	2 39	2
Oats ..	5-year rotation Wooster....	6	4.39	2	2.91	4	3.48	3	4.41	1
	5-year rotation Strongsville	4	3.67	3	3.33	4	4.10	2	4.59	1
	Continuous Columbus ..	10	2.22	2	...	.....	.....	......	2.52	1
Wheat.	5-year rotation Wooster....	6	9.20	1	8.53	2	6.69	4	7.14	3
	5-year rotation Strongsville	3	9.27	1	6.87	4	7.83	3	8.49	2
	3-year rotation Wooster....	5	6.49	3	6.27	4	6.65	2	6.74	1
	3-year rotation Strongsville	3	12.61	1	10.70	2	10.08	3	9.06	4
	Continuous Columbus ..	7	5.01	1	.....	.....	......	......	4.16	2
Hay ...	Hay, all tests .	17	1.95	1	1.71	3	1.81	2	1.43	4

SUMMARY.

Corn ..	5-year rotations ...	9	4.02	1	2.27	4	2.60	3	3.16	2
Oats ..	5-year rotations ...	10	4.10	2	3.16	4	3.73	3	4.33	1
Wheat.	Both rotations	17	9.03	1	7.89	2	7.48	4	7.56	3
Hay ...	" "	17	1.95	1	1.71	3	1.81	2	1.43	4

oil-meal and dried blood. At Columbus a similar comparison has been made between nitrate of soda and sulphate of ammonia, on Plots 11 and 15, but the 1,000 pounds of oil-meal per acre, used on Plot 21 in that test, carries an excess of nitrogen and a deficiency of phosphoric acid and potash, hence that plot cannot be compared with the oil-meal plots at Wooster and Strongsville.

The results of this comparison are given in Table XLI, which shows the value of the average increase per acre, as found in the different tests, with the relative rank of the nitrogen carriers. This table gives to nitrate of soda decidedly the first rank as a nitrogen carrier for corn and wheat, the only exception being found in the shorter rotation at Wooster, where, however, the difference is so small in all cases as to indicate a practical equality of all three carriers on that particular soil.

With oats, however, sulphate of ammonia has given the best results in every case, although the difference at Wooster is very small. Sulphate of ammonia takes, in the general average, the second place for corn, while the difference between dried blood and linseed oil-meal is so small that no decided superiority can be ascribed to either. If we consolidate the values given in the summary of this table, as representing the probable outcome of an average rotation, in which the four crops have followed each other as in our actual rotations, we shall have the following as the value of the total increase per acre from each carrier of nitrogen, when reënforced, as in these tests, with sufficient and uniform quantities of phosphoric acid and potash:

From nitrate of soda	$19.10
" sulphate of ammonia	16.48
" dried blood	15.62
" linseed oil-meal	15.03

Taking nitrate of soda as 100, these figures would give the following as the relative effectiveness of these nitrogen carriers.

Nitrate of soda	100
Sulphate of ammonia	86
Dried blood	82
Linseed oil-meal	79

CARRIERS OF PHOSPHORIC ACID.

The fertilizing of Plots 11, 26, 27 and 29 in the rotations at Wooster and Strongsville, and of Plots 11, 17 and 18 at Columbus, has been planned as a test of the availability of phosphoric acid in different carriers. The total quantity of phosphoric acid given in the different carriers is the same, as are also the quantities of nitrogen and potash, the nitrogen being given in nitrate of soda alone on corn and oats, or three-fourths nitrate of soda and one-fourth dried blood on wheat, except on Plot 26, where the

TABLE XLII. VALUE OF AVERAGE INCREASE FROM DIFFERENT CARRIERS OF PHOSPHORIC ACID

Crops	Culture	Number of crops gr'wn	Carriers of phosphoric acid							
			Acid phosphate		Raw bone-meal		Dissolved bone-black		Basic slag	
			Av'ge value of increase	Rank	Av'ge value of increase	Rank	Av'ge value of increase	Rank	Av'ge value of increase	Rank
Corn...	5-year rotation Wooster....	5	$3.42	1	$2.65	4	$3.33	3	$3.36	2
	5-year rotation Strongsville.	4	2.99	3	1.85	4	3.38	1	3.36	2
	Continuous Columbus ..	11	3.41	1	......	......	2.33	3	3.11	2
Oats...	5-year rotation Wooster....	6	3.97	2	3.47	3	4.41	1	3.41	4
	5-year rotation Strongsville.	4	3.48	4	4.08	3	4.30	1	4.17	2
	Continuous Columbus ..	10	2.30	2	......	.....	2.64	1	2.12	3
Wheat.	5-year rotation Wooster....	6	8.26	2	6.92	4	8.61	1	7.38	3
	5-year rotation Strongsville.	3	7.81	4	9.77	2	8.70	3	11.13	1
	3-year rotation Wooster....	5	6.39	4	7.54	3	7.66	2	8.11	1
	3-year rotation Strongsville.	3	12.99	3	13.20	2	10.58	4	13.68	1
	Continuous Columbus ..	7	3.63	3	.....	......	4.16	1	3.74	2
Hay ...	All tests......	17	6.29	4	1.91	3	1.92	2	2.70	1

SUMMARY.

Corn...	5-year rotations.......	9	$3.23	3	$2.30	4	$3.35	2	$3.36	1
Oats...	5-year rotations.......	10	3.77	2	3.71	3	4.37	1	3.71	3
Wheat.	Both rotations	17	8.24	4	8.71	2	8.68	3	9.37	1
Hay ...	"	17	1.29	4	1.91	3	1.92	2	2.70	1

nitrogen in the bone meal takes the place of the dried blood and a part of the nitrate of soda. (See plans of fertilizing, pp. 10 and 21.)

Up to 1897, dissolved bone-black was used as the standard carrier of phosphoric acid in all our tests, but as acid phosphate has almost completely displaced dissolved bone-black in the fertilizers used in Ohio, it seemed desirable to use this material as our standard. This change was made in the spring of 1897, and at the same time the carrier of phosphoric acid on Plot 27, which had previously been acid phosphate, was changed to dissolved bone-black. Up to 1898 the acid phosphate used on this plot was made from South Carolina rock, and was used on the basis of 14 per cent. available phosphoric acid, against 16 per cent. available in the dissolved bone-black; but beginning with that season, Tennessee acid phosphate, 16 per cent. grade, has been substituted. The results of this comparison are given in Table XLII:

From this table it appears that basic slag has taken the first rank as a carrier of phosphoric acid on three crops, and the third by a very small margin, on the fourth; and that dissolved bone-black, acid phosphate and raw bone-meal follow, with but small differences between.

Making the same summing up in this test as in the case of the nitrogen comparison, we find that the total average value of increase from different carriers of phosphoric acid in the three crops, the nitrogen and potash remaining uniform, has been as follows:

From basic slag	$19.04
" dissolved bone-black	18.32
" raw bone-meal	16.63
" acid phosphate	16.53

Taking basic slag as 100, we find the following relative values of these materials as carriers of phosphoric acid:

Basic slag	100
Dissolved bone-black	96
Raw bone-meal	87
Acid phosphate	87

When results run so close together as they do in some of these comparisons further work is required to definitely determine their relative values.

The potatoes have not been included in these comparisons of carriers of nitrogen and phosphoric acid, for the reason that the general results on the plots used in these experiments have not, as yet, been sufficiently harmonious, in the case of potatoes, to justify their use.

SUMMARY.

On soils formed chiefly from the argillaceous shales of the Waverly series, phosphoric acid is found to be the constituent of fertility first required by corn, oats, wheat and potatoes; but the maximum yield has not been obtained until both nitrogen and potash were also added.

When used alone, or in combination with each other only, nitrogen and potash have produced but a very small increase, and have always been thus used at a heavy financial loss.

The complete fertilizer, containing all three constituents, has produced a much larger total increase than the sum of the increase produced by the constituents used separately.

When the cereal crops have been grown continuously on the same land the maximum increase of crop, per pound of fertilizing constituents applied, has been obtained when these constituents were used in approximately the same ratio to each other in which they are found in the crop; but the total recovery of fertilizing constituents in increase of crop, under continuous cropping, has never exceeded sixty per cent. of the quantity applied in the fertilizer.

When the cereals have been grown in rotation with clover the recovery of nitrogen has, under favorable conditions, exceeded the amount applied in the fertilizer; but even under these conditions the recovery of phosphoric acid and potash has remained far below the quantity applied in the fertilizer, when maximum yields were reached.

Thus far in these experiments, the surplus nitrogen accumulated by a crop of clover, the roots only being left in the ground, has not been more than sufficient to satisfy the demands of the one crop immediately following the clover.

At the prices at which mixed fertilizers are sold in Ohio the attempt to furnish all the nitrogen, as well as all the phosphoric acid and potash required to produce increase in cereal crops grown in continuous culture, has invariably resulted in pecuniary loss, although very large increase of crop has been thus produced.

The rotation of cereals with nitrogen gathering crops, therefore, has been shown to be absolutely essential to the profitable use of commercial fertilizers in any form.

The increase of crop per pound of fertilizing constituents applied has generally been smaller, when barnyard manure was used as the carrier of fertility, than when chemical carriers were used; but the lower cost of barnyard manure has made it possible to use this material with profit when the use of commercial fertilizers resulted in loss.

A marked superiority is indicated from manure which has been kept under cover until required for use, over that which has been exposed, even for but a short time, in an open barnyard, and it seems possible to materially increase the effectiveness of manure by treating it with nitrogen-fixing materials.

Nitrate of soda has shown itself to be the most effective of the carriers of nitrogen employed in these experiments, with sulphate of ammonia, dried blood and linseed oil-meal following in the order named.

Of the four carriers of phosphoric acid used, basic slag and dissolved bone-black show the highest effectiveness, with raw bone meal and acid phosphate not far below.

The tendency to excessive production of straw in wheat and oats is apparently due in part to climatic, and in part to soil conditions, and the remedy apparently lies in systematic rotation, combined with judicious selection and distribution of fertilizing materials.

APPENDIX.

In the tables which follow are given the yields of the crops in the various experiments which have been discussed in the preceding pages. In the great majority of cases these are actual yields; but under some circumstances, as when there has been great lack of uniformity of stand, it has seemed that the actual lesson of the experiment could only be reached by correcting the yields on the basis of the actual stand. The corrected yields are indicated by asterisks.

As shown by the diagrams, or field plans, included in this report, every third plot, beginning with No. 1 in each test, is left continuously unfertilized throughout all the work. In calculating the increase from the fertilizers, it has been assumed that the variations between neighboring unfertilized plots are more likely to be due to gradual than to abrupt changes in the character of the soil, and therefore, instead of taking the simple average of two unfertilized plots, a progressive average has been ascertained, by taking one-third of the difference between the yields of the unfertilized plots and adding this to the smaller yield and subtracting it from the larger yield, to get the probable unfertilized yield of the adjoining plots. To illustrate: If the yield of Plot 1 were 20 bushels and that of Plot 4 were 23 bushels, it would be assumed that Plot 2 should have yielded 21 bushels and Plot 3, 22 bushels, if left unfertilized.

While this method will not always give the actual fact, many trials have shown that the results thus obtained are very much more consistent, taken as a whole, than can be arrived at by taking simple averages. In no case are any but the most general conclusions drawn from the general average of all the unfertilized plots.

TABLE XLIII: YIELDS OF CORN IN 5-YEAR ROTATION—WOOSTER.

Plot	Bushels of ear-corn per acre (1 bu.=70 lbs.)						Pounds of stover per acre					
	1894	1895	1896	1897	1898	Average	1894	1895	1896	1897	1898	Average
1	17.28	40.57	55.64	18.82	27.07	31.88	1,270	2,640	1,750	1,320	970	1,614
2	17.64	44.21	54.21	24.64	39.43	36.02	1,250	2,560	1,480	1,640	1,180	1,622
3	16.92	39.57	53.89	34.93	29.36	34.93	1,300	2,330	1,610	2,100	1,140	1,696
4	16.17	40.46	47.57	31.54	26.43	32.43	1,170	2,590	1,580	1,820	980	1,628
5	15.50	38.07	54.43	31.57	37.32	35.38	1,120	2,610	1,560	1,780	1,300	1,674
6	19.46	51.07	61.68	40.46	43.93	43.32	1,210	2,600	1,790	2,110	1,380	1,818
7	18.00	39.07	59.64	27.93	26.82	34.29	1,250	2,480	1,620	1,600	990	1,588
8	21.07	41.71	61.43	35.93	40.43	40.11	1,310	2,550	1,860	2,100	1,340	1,832
9	15.92	29.18	57.68	30.32	31.89	33.00	1,110	2,390	1,870	1,840	1,120	1,666
10	17.71	31.07	53.93	24.57	23.36	30.13	1,150	2,050	1,600	1,600	920	1,464
11	20.46	42.14	68.57	33.89	41.36	41.28	1,350	2,480	1,950	1,900	1,420	1,821
12	24.85	41.04	63.32	37.18	38.96	41.07	1,400	2,390	2,080	2,050	1,250	1,824
13	25.35	32.93	53.71	23.75	21.82	31.41	1,410	2,270	1,700	1,460	960	1,564
14	25.42	38.11	65.36	33.11	42.79	40.96	1,550	2,590	2,170	1,990	1,320	1,924
15	22.17	....	53.32	22.54	31.00	32.26	1,390	2,600	1,890	1,600	970	1,690
16	21.07	*35.29	49.71	15.36	24.64	27.69	1,400	2,680	1,810	1,240	980	1,622
17	20.50	....	56.89	31.79	33.93	35.78	1,340	2,770	1,700	2,050	1,150	1,802
18	17.78	....	58.75	45.96	40.43	40.73	1,350	3,010	1,970	2,700	1,270	2,060
19	21.22	36.86	53.86	25.32	28.32	33.12	1,270	2,780	1,680	1,630	980	1,668
20	17.28	37.21	55.68	44.54	39.86	38.91	1,260	2,650	1,940	2,480	1,320	1,930
21	22.07	36.36	54.86	37.39	37.64	37.66	1,500	2,630	1,950	2,200	1,140	1,884
22	17.17	32.14	44.79	23.57	28.29	29.19	1,170	2,280	1,630	1,650	1,040	1,554
23	16.10	41.07	55.00	37.60	38.64	37.68	1,200	2,600	1,850	2,420	1,200	1,854
24	20.21	37.89	62.00	42.07	40.36	40.51	1,300	2,720	2,200	2,390	1,330	1,988
25	17.35	32.21	50.96	32.36	24.82	31.54	1,100	2,390	1,660	2,200	950	1,660
26	18.32	36.36	59.43	42.86	38.75	39.14	1,320	2,670	2,240	2,550	1,270	2,010
27	15.50	36.71	62.04	41.14	47.64	40.61	1,150	2,510	1,950	2,520	1,600	1,946
28	14.85	33.21	50.16	35.43	44.89	35.71	1,140	2,220	1,850	2,100	1,530	1,768
29	14.96	42.79	62.36	44.68	54.68	43.89	1,100	2,790	2,150	2,590	1,870	2,100
30	14.60	49.36	57.68	40.82	46.18	41.73	1,070	2,680	1,920	2,390	1,400	1,892

TABLE XLIV. YIELDS OF CORN IN 5-YEAR ROTATION — STRONGSVILLE.

Plot	Bushels of ear-corn per acre (1 bu. = 70 lbs.)					Pounds of stover per acre				
	1895	1896	1897	1898	Av'ge	1895	1896	1897	1898	Av'ge
1	37.21	22.50	24.71	32.21	29.16	1,700	1,300	1,450	1,240	1,422
2	38.00	27.21	24.86	31.14	30.30	1,450	1,270	1,630	1,060	1,352
3	36.36	25.79	19.71	21.86	25.93	1,600	1,350	1,240	950	1,285
4	33.21	24.79	15.65	19.50	23.29	1,410	1,420	1,220	950	1,250
5	35.29	28.79	13.00	19.36	24.11	1,520	1,480	1,200	940	1,285
6	41.71	32.29	19.00	25.64	29.66	1,460	1,585	1,240	1,040	1,331
7	36.43	22.64	12.50	19.50	22.77	1,700	1,265	1,450	940	1,339
8	38.00	21.29	22.07	29.79	27.79	1,480	1,100	1,020	1,140	1,185
9	35.21	25.43	17.00	25.36	25.75	1,540	1,225	1,420	1,070	1,314
10	29.43	24.00	23.14	29.79	26.59	1,820	1,140	1,430	1,220	1,402
11	42.79	34.71	36.86	35.43	37.45	1,830	1,430	1,940	1,360	1,640
12	43.36	32.29	33.57	35.71	36.23	1,830	1,530	1,860	1,430	1,662
13	39.29	25.14	25.86	29.14	29.86	1,930	1,190	1,480	1,220	1,455
14	46.79	33.71	27.21	33.71	35.35	2,100	1,440	1,700	1,540	1,695
15	41.14	25.14	16.14	27.79	27.55	1,830	1,265	1,340	1,170	1,401
16	36.29	36.79	18.64	32.29	31.00	2,230	1,715	1,360	1,290	1,649
17	41.71	30.36	26.36	35.57	33.50	2,250	1,615	1,520	1,300	1,671
18	45.07	39.64	25.57	44.43	38.68	2,400	1,800	1,440	1,600	1,810
19	32.50	31.79	21.29	34.07	29.91	2,550	1,565	1,330	1,300	1,686
20	38.50	33.50	32.79	41.07	36.46	2,570	1,575	1,650	1,400	1,799
21	40.14	17.71	33.29	34.79	31.48	2,750	1,150	1,680	1,460	1,760
22	38.14	16.07	26.50	34.36	28.77	3,100	1,060	1,340	1,360	1,715
23	49.57	18.36	28.36	41.00	34.32	2,650	1,120	1,560	1,420	1,687
24	50.14	15.07	32.00	39.21	34.10	2,850	1,110	1,860	1,450	1,817
25	46.43	12.86	24.50	29.07	28.21	2,950	1,040	1,560	1,250	1,700
26	50.21	14.21	24.57	37.50	31.62	3,060	1,190	1,680	1,460	1,847
27	52.07	16.50	27.50	35.21	32.82	2,930	1,180	1,700	1,450	1,815
28	44.57	11.43	14.36	30.36	25.18	2,610	950	1,220	1,350	1,532
29	51.21	19.50	28.86	39.50	34.77	2,490	1,110	1,660	1,470	1,682
30	54.50	24.86	29.00	45.86	38.55	2,636	1,200	1,520	1,460	1,702
31	45.07	16.50	17.57	29.21	27.09	2,500	980	1,380	1,300	1,540
32	....	18.43	25.36	44.29	29.36	....	1,135	1,520	1,450	1,368
33	....	23.00	22.50	45.93	30.48	....	1,250	1,240	1,640	1,377
34	....	17.86	14.71	39.36	23.98	....	1,290	1,350	1,600	1,413
35	....	29.50	22.36	40.64	30.83	....	1,625	1,340	1,620	1,528
36	....	32.57	25.79	51.57	36.64	....	1,650	1,560	2,070	1,760
37	....	25.36	19.86	41.93	29.05	....	1,470	1,360	1,450	1,427
38	....	26.93	16.00	41.00	27.98	....	1,490	1,320	1,000	1,470
39	....	29.21	12.93	33.64	25.26	....	1,460	1,060	1,450	1,323
40	....	28.29	19.64	30.86	26.26	....	1,500	1,360	1,400	1,420

TABLE XLV. YIELDS OF OATS IN 5-YEAR ROTATION — WOOSTER.

Plot	Bushels of grain per acre (1 bu. = 32 lbs.)							Pounds of straw per acre						
	1894	1895	1896	1897	1898	1899	Average	1894	1895	1896	1897	1898	1899	Average
1	23.2[illegible]	30.62	31.56	42.18	33.44	33.10	32.35	907	1,120	1,410	1,250	1,480	1,000	1,194
2	28.28	34.68	35.39	47.18	42.65	46.25	39.07	1,145	1,240	1,427	1,460	1,435	1,540	1,374
3	24.44	28.36	32.65	44.06	44.06	34.69	34.71	817	992	1,415	1,220	1,990	1,020	1,242
4	26.10	26.40	30.23	40.00	39.68	34.68	32.85	1,165	960	1,632	1,110	1,680	1,050	1,266
5	29.84	26.87	33.91	45.94	40.46	40.46	36.25	1,245	940	1,215	1,430	1,745	1,315	1,315
6	31.25	35.70	42.81	48.44	43.59	52.65	42.41	1,400	1,158	1,780	1,350	2,055	1,745	1,581
7	25.86	26.25	29.92	40.31	37.18	34.53	32.34	1,022	1,010	1,422	1,110	1,540	1,025	1,188
8	30.15	36.17	33.12	48.44	43.44	49.37	40.11	1,335	1,232	1,420	1,480	1,930	1,570	1,494
9	25.15	26.64	25.78	48.75	40.47	37.97	34.13	945	908	1,195	1,510	1,935	1,205	1,283
10	24.14	25.54	21.02	44.87	36.87	36.41	31.39	1,127	933	857	1,180	1,740	1,025	1,144
11	33.28	37.57	37.34	61.56	48.28	58.60	46.10	1,485	1,368	1,725	2,080	2,385	2,035	1,846
12	30.31	40.46	42.42	62.50	49.84	58.12	47.27	1,580	1,555	1,782	2,450	2,395	2,140	1,984
13	21.33	28.91	24.22	41.87	40.15	35.46	31.99	1,067	1,315	1,135	1,360	1,440	1,085	1,225
14	26.02	41.56	31.87	44.37	40.15	43.12	37.85	1,367	1,480	1,580	1,230	1,965	1,390	1,502
15	21.80	30.23	23.91	38.75	36.87	36.25	31.30	1,052	982	985	1,160	1,510	1,040	1,655
16	20.55	28.75	24.84	36.56	35.31	33.44	29.91	1,292	880	1,155	1,050	1,380	950	1,118
17	23.67	37.90	35.00	47.50	46.09	54.69	40.81	1,442	1,215	1,540	1,390	2,175	1,840	1,600
18	20.70	37.03	31.25	36.87	42.50	44.22	38.31	1,037	1,455	1,320	1,040	1,990	1,415	1,444
19	22.27	28.51	26.09	36.87	36.09	34.53	30.73	1,137	988	1,075	890	1,545	1,005	1,107
20	23.98	34.22	26.56	37.50	39.68	44.06	34.33	1,632	1,105	1,060	1,050	1,730	1,410	1,331
21	32.34	29.06	30.31	50.31	45.15	55.78	40.49	1,415	1,070	1,590	1,470	2,255	2,025	1,637
22	28.28	25.78	20.15	37.18	36.09	35.00	30.41	1,145	1,065	935	860	1,845	1,020	1,146
23	32.66	36.09	31.56	52.18	46.56	58.12	42.86	1,505	1,155	1,140	1,700	1,670	2,120	1,548
24	32.81	37.65	36.94	58.12	49.53	59.06	45.68	1,450	1,445	1,617	1,790	2,655	2,200	1,859
25	28.91	28.90	21.41	36.56	37.34	34.37	31.25	1,275	1,075	1,025	1,230	1,855	1,020	1,247
26	35.47	36.48	36.09	56.87	50.81	50.81	44.25	1,865	1,252	1,585	1,780	2,090	1,690	1,619
27	37.50	38.04	37.81	57.50	51.87	61.09	46.47	1,750	1,182	1,620	1,880	2,190	2,175	1,799
28	35.78	25.78	20.94	37.18	38.12	45.62	33.90	1,505	755	900	1,090	1,780	1,520	1,258
29	39.22	31.40	41.09	49.67	51.09	59.37	45.81	1,895	955	1,865	1,410	2,225	2,100	1,748
30	37.19	32.65	37.19	33.43	36.87	56.87	39.08	1,560	1,125	1,690	780	1,560	1,990	1,451

TABLE XLVI. YIELDS OF OATS IN 5-YEAR ROTATION — STRONGSVILLE.

Plot	Bushels of grain per acre (1 bu. — 32 lbs.)					Pounds of straw per acre				
	1896	1897	1898	1899	Av'ge	1896	1897	1898	1899	Av'ge
1	26.17	30.31	41.09	33.59	32.79	1,337	890	1,845	1,295	1,342
2	30.23	40.62	51.25	45.78	41.97	1,732	1,240	2,080	1,535	1,647
3	23.36	34.37	44.84	32.50	33.77	1,472	940	1,765	860	1,259
4	23.67	34.22	37.42	30.31	31.40	1,432	965	1,332	800	1,132
5	23.44	34.06	36.25	33.12	31.72	1,745	970	1,310	940	1,242
6	35.94	45.62	50.86	47.34	44.94	1,815	1,320	1,832	1,455	1,605
7	28.52	32.97	34.53	31.17	31.80	1,567	925	1,105	832	1,107
8	31.09	41.56	50.00	51.41	43.51	1,730	1,230	1,870	1,595	1,606
9	26.09	31.56	42.81	44.45	36.23	2,085	890	1,460	1,477	1,465
10	20.70	30.00	47.65	44.69	35.76	1,287	960	1,715	1,470	1,358
11	33.12	42.50	64.06	53.98	48.41	19.35	1,480	2,800	1,722	1,984
12	34.22	43.33	65.47	56.72	49.93	2,010	1,630	2,635	1,985	2,065
13	25.23	35.47	49.84	38.44	37.24	1,782	1,085	2,085	1,250	1,550
14	31.33	38.44	52.19	41.64	40.90	1,872	1,230	2,050	1,267	1,605
15	27.81	31.72	41.33	36.25	34.28	1,615	1,025	1,427	1,140	1,302
16	22.58	36.22	43.75	35.00	34.39	1,337	1,120	1,570	1,000	1,257
17	31.64	34.58	59.06	54.14	44.84	1,912	1,135	2,560	1,687	1,823
18	28.20	38.28	49.06	41.25	39.20	1,487	1,285	1,810	1,260	1,460
19	18.12	33.12	44.53	35.46	32.81	1,300	980	1,425	1,115	1,205
20	25.78	30.31	52.58	41.72	37.60	1,570	1,130	1,997	1,315	1,503
21	27.87	39.69	60.70	58.36	46.65	2,087	1,270	2,907	2,082	2,086
22	28.28	33.12	51.01	38.59	37.75	1,755	940	2,337	1,345	1,594
23	32.50	44.38	64.84	56.25	49.49	2,770	1,420	3,275	1,950	2,353
24	35.69	43.60	63.91	52.66	48.96	28.47	1,405	2,885	1,835	2,243
25	29.38	28.28	45.78	32.81	34.06	2,270	795	1,945	1,100	1,527
26	41.25	40.31	58.44	50.23	47.56	2,525	1,210	2,220	1,572	1,882
27	37.03	43.75	58.20	46.87	46.46	2,640	1,340	2,237	1,470	1,922
28	29.64	28.44	36.84	33.75	32.22	1,340	890	1,061	920	1,178
29	39.53	38.91	56.17	47.50	45.53	2,260	1,255	2,202	1,430	1,787
30	35.94	34.84	45.31	53.36	42.36	2,300	1,065	1,480	1,722	1,642
31	25.16	24.84	39.30	31.17	30.12	1,800	805	1,422	982	1,252
32	37.19	33.44	53.75	47.19	42.89	2,515	1,030	1,900	1,530	1,744
33	37.73	35.31	48.98	46.80	42.20	2,567	1,150	1,972	1,632	1,830
34	24.84	25.62	37.11	33.05	30.15	1,755	800	1,192	1,142	1,222
35	36.80	37.66	51.95	47.50	43.48	2,392	1,275	2,087	1,680	1,858
36	36.87	37.66	51.80	46.09	43.10	2,315	1,235	1,822	1,625	1,749
37	21.38	27.81	38.12	33.67	30.23	1,672	830	1,390	1,182	1,268
38	27.73	30.94	35.78	30.36	31.20	2,363	810	1,085	1,027	1,321
39	33.67	30.62	33.36	28.12	31.44	1,882	840	1,112	980	1,191
40	22.97	29.22	30.69	26.25	29.53	1,815	885	1,270	730	1,175

TABLE XLVII: YIELDS OF WHEAT IN 5-YEAR ROTATION — WOOSTER.

Plot	Bushels of grain per acre (1 bu.—60 lbs.)							Pounds of straw per acre						
	1894	1895	1896	1897	1898	1899	Average	1894	1895	1896	1897	1898	1899	Average
1	13.54	1.42	0.87	14.25	13.87	4.42	8.06	1,437	115	127	1,645	1,397	685	898
2	13.62	6.50	4.00	20.58	17.04	11.42	12.19	2,382	310	530	2,235	1,627	1,215	1,383
3	24.92	1.17	1.67	14.67	13.87	8.50	10.80	2,805	230	230	1,500	1,367	1,090	1,204
4	22.17	2.58	0.96	12.17	12.29	7.67	9.64	2,620	285	162	1,240	1,112	1,140	1,093
5	20.54	3.83	1.87	17.00	15.12	9.00	11.14	2,517	440	277	1,900	1,502	1,210	1,308
6	16.71	9.50	4.92	27.83	25.25	17.67	16.98	2,847	710	655	3,490	2,335	1,890	1,988
7	20.95	2.08	0.75	12.17	14.16	5.83	9.32	2,642	175	95	1,290	1,450	810	1,077
8	18.87	9.42	6.50	20.42	20.79	15.08	15.18	2,467	685	670	2,258	1,722	1,535	1,555
9	22.54	3.17	2.37	14.17	18.21	8.50	11.49	2,497	260	260	1,400	1,927	1,230	1,262
10	18.04	3.17	1.21	9.83	17.21	5.33	9.13	1,967	210	277	1,010	1,647	770	980
11	18.54	10.83	9.04	30.58	33.67	22.83	20.91	3,087	860	1,057	3,665	3,110	2,580	2,393
12	20.29	11.83	6.37	34.33	31.92	24.67	21.57	3,382	880	717	4,150	3,035	2,820	2,497
13	20.79	2.67	1.42	9.83	13.46	6.25	9.07	2,352	190	265	1,050	1,292	725	979
14	18.79	7.33	8.08	28.83	27.50	19.42	18.32	3,322	660	975	3,420	2,500	2,235	2,185
15	18.37	7.83	4.00	27.92	25.75	18.67	17.09	3,047	580	510	3,125	2,455	2,040	1,959
16	19.04	2.08	1.41	9.33	9.54	5.17	7.76	2,207	225	215	960	777	630	836
17	21.04	8.83	6.04	17.33	15.96	14.67	13.98	2,887	640	767	2,030	1,402	1,650	1,563
18	16.96	6.42	7.00	17.41	15.46	15.83	13.18	2,882	745	1,030	1,925	1,312	1,960	1,642
19	18.21	2.83	1.45	9.00	10.04	7.08	8.10	1,957	280	212	840	927	835	842
20	17.46	7.17	4.79	12.92	15.04	13.50	11.81	2,752	670	612	1,495	1,267	1,570	1,394
21	20.37	8.75	8.54	28.33	25.75	22.75	19.08	3,377	775	937	3,320	2,185	2,705	2,216
22	17.54	2.17	0.75	8.00	11.87	9.08	8.23	1,997	220	255	730	1,087	1,005	882
23	19.04	10.92	6.58	21.42	25.92	20.17	17.34	3,057	895	665	2,265	2,185	2,490	1,926
24	21.54	11.92	6.70	23.42	25.67	21.17	18.40	3,407	535	847	2,675	2,120	2,630	2,036
25	22.21	3.58	1.16	9.83	12.12	9.25	9.69	2,517	335	160	910	1,072	1,105	1,016
26	18.54	11.17	6.16	26.17	28.83	20.17	18.51	3,187	880	920	2,870	2,570	2,280	2,118
27	15.62	17.58	5.16	28.00	27.92	22.92	19.53	3,112	1,545	590	2,930	2,425	2,575	2,196
28	20.37	7.25	0.66	9.92	11.71	8.50	9.73	2,277	715	70	865	1,047	990	994
29	18.29	15.58	6.58	23.83	24.25	21.50	19.17	3,152	1,315	665	3,300	2,045	2,390	2,144
30	15.79	17.00	4.62	18.92	16.96	17.42	15.12	2,752	1,130	702	1,985	1,332	1,825	1,621

TABLE XLVIII: YIELDS OF WHEAT IN 5-YEAR ROTATION—STRONGSVILLE.

Plot	Bushels of grain per acre (1 bu.—60 lbs.)				Pounds of straw per acre			
	1897	1898	1899	Av'ge	1897	1898	1899	Av'ge
1	10.33	1.67	5.17	5.72	860	170	490	507
2	24.93	7.46	8.67	13.69	3,090	683	920	1,564
3	13.08	1.71	3.25	6.01	1,215	218	165	531
4	16.50	1.67	3.17	7.11	1,590	250	290	710
5	15.17	2.54	2.08	6.60	1,410	308	195	638
6	30.17	13.00	11.00	18.06	3,490	1,220	920	1,877
7	16.50	1.42	2.17	6.70	1,630	165	150	648
8	23.08	11.67	8.92	14.56	2,555	1,100	635	1,430
9	20.00	3.12	3.75	8.96	2,160	343	375	959
10	13.92	2.08	3.83	6.61	1,425	255	380	687
11	25.67	15.67	15.92	19.09	2,660	1,530	1,295	1,828
12	33.67	16.12	20.83	23.54	3,930	1,633	2,050	2,538
13	12.83	2.25	6.17	7.08	1,190	275	600	688
14	29.33	16.50	17.33	21.05	3,220	1,470	1,620	2,103
15	27.00	14.08	14.75	18.61	2,880	1,165	1,345	1,797
16	15.67	2.67	5.00	7.78	1,480	330	300	703
17	16.17	9.67	12.25	12.70	1,510	940	1,145	1,198
18	27.67	15.17	10.25	17.70	2,980	1,350	955	1,762
19	8.83	2.00	4.00	4.94	770	180	210	387
20	20.00	9.17	10.42	13.20	1,900	910	915	1,242
21	18.04	12.83	17.33	16.07	1,737	1,080	2,060	1,626
22	15.08	1.50	8.00	8.19	1,495	180	700	792
23	24.50	11.75	17.92	18.06	2,450	995	2,190	1,878
24	28.67	10.00	17.08	18.58	2,900	790	2,185	1,958
25	14.04	1.58	6.00	7.21	1,357	205	625	729
26	29.58	13.42	17.67	20.22	3,005	1,145	1,965	2,038
27	23.50	12.25	15.67	17.14	2,310	1,055	1,650	1,672
28	18.58	*1.88	2.83	7.76	1,745	228	255	743
29	32.00	17.83	15.50	21.78	3,400	1,440	1,635	2,158
30	29.58	13.67	9.92	17.72	3,265	1,140	950	1,785
31	13.12	1.92	2.67	5.90	1,212	215	285	571
32	27.75	12.00	13.00	17.58	2,935	1,000	1,300	1,745
33	22.75	11.08	11.14	14.99	2,315	855	635	1,268
34	16.37	1.37	2.50	6.75	1,597	178	250	675
35	28.83	11.62	13.83	18.09	2,870	1,023	1,390	1,761
36	32.00	10.33	14.00	18.78	3,380	960	1,385	1,908
37	15.83	0.71	3.00	6.51	1,370	86	295	584
38	27.83	11.08	11.25	16.72	2,870	945	1,310	1,708
39	24.33	7.37	5.92	12.54	2,260	658	565	1,161
40	16.50	1.00	3.33	6.94	1,470	121	280	624

TABLE XLIX: YIELDS OF HAY IN 5-YEAR ROTATION — WOOSTER.

Pounds per acre

Plot	First-year crops, (clover)					Second-year crops, (timothy)				
	1895	1896	1897	1898	Average	1896	1897	1898	1899	Average
1	1,300	1,370	1,660	1,180	1,377	3,800	2,710	1,150	2,500	2,540
2	1,300	2,360	2,730	1,490	1,970	3,000	3,290	1,500	2,460	2,562
3	1,820	1,600	1,910	1,610	1,735	4,550	3,240	1,250	2,040	2,770
4	1,860	1,700	1,890	1,640	1,772	4,050	2,760	900	1,940	2,412
5	1,360	2,460	2,320	1,230	1,842	3,500	3,520	1,330	2,340	2,672
6	1,300	3,320	3,930	2,550	2,775	3,380	4,100	1,770	2,560	2,952
7	1,100	1,450	2,060	2,100	1,677	3,650	2,590	1,050	1,900	2,297
8	1,280	2,350	3,960	2,300	2,472	4,030	3,000	1,200	2,020	2,562
9	1,600	1,960	2,560	1,970	2,022	4,050	2,710	1,150	1,700	2,402
10	1,260	1,350	2,090	1,880	1,645	3,700	2,610	650	1,520	2,120
11	1,100	3,050	4,350	2,460	2,740	3,450	3,580	1,800	2,800	2,907
12	1,440	3,450	4,270	2,600	2,940	3,000	2,800	1,900	2,760	2,615
13	1,280	1,210	2,510	2,320	1,830	3,920	2,280	850	1,740	2,197
14	1,380	2,820	4,310	2,750	2,815	3,520	3,520	1,400	2,720	2,790
15	1,420	1,980	3,390	2,320	2,277	3,570	2,550	1,350	2,660	2,532
16	1,120	1,140	2,060	2,120	1,610	3,750	2,420	960	2,000	2,280
17	1,280	2,770	3,660	2,650	2,590	4,000	2,850	1,550	2,340	2,685
18	1,640	3,870	4,660	2,350	3,130	4,950	3,600	2,850	3,000	3,475
19	1,020	1,650	2,540	1,910	1,780	3,710	2,600	1,010	2,340	2,415
20	1,400	3,400	3,310	2,090	2,550	4,650	3,900	1,570	2,040	3,040
21	1,280	2,560	4,060	2,170	2,517	4,150	2,950	1,050	2,100	2,562
22	1,330	1,050	1,940	1,680	1,500	3,840	2,250	550	1,400	2,010
23	1,160	2,750	4,100	2,030	2,510	4,100	3,200	1,050	1,820	2,542
24	1,140	2,700	3,590	2,250	2,420	4,030	3,300	850	1,740	2,480
25	1,260	1,580	2,030	1,900	1,692	4,350	2,800	740	1,540	2,357
26	1,180	4,000	3,600	1,800	2,645	4,100	4,600	1,400	2,340	3,110
27	1,120	3,650	2,740	1,900	2,350	3,980	4,650	1,380	2,230	3,060
28	1,460	2,400	1,300	1,600	1,690	4,380	4,530	670	1,260	2,707
29	1,240	3,760	3,390	1,750	2,535	4,200	5,050	2,120	3,260	3,657
30	1,100	3,400	3,230	2,150	2,470	4,540	5,100	1,750	3,000	3,597

"In harvesting the hay the mowing machine is driven to stakes * * * the grass growing in the dividing spaces being left until the hay on the plots is cured, weighed and hauled away."

Plot 10, unfertilized.

Plot 11, complete fertilizer.

POTATOES IN 3-YEAR ROTATION, WOOSTER.

Plot 1, unfertilized.

Plot 2, complete fertilizer.

CORN IN CONTINUOUS CULTURE, WOOSTER.

TABLE L. YIELDS OF HAY IN ROTATIONS AT STRONGSVILLE

Pounds of hay per acre

Plot	5-year rotation					3-year rotation
	1st-year crop (clover)				2d. year crop	
	1897	1898	1899	Average	1898	1897
1	1,550	1,400	760	1,237	2,260	1,560
2	2,070	2,040	2,220	2,110	1,560	1,760
3	1,560	1,080	1,060	1,233	1,480	1,120
4	1,010	1,340	1,020	1,123	1,440	1,060
5	1,340	2,040	1,500	1,627	1,400	2,000
6	2,040	2,260	2,540	2,280	1,450	1,160
7	2,180	2,380	1,200	1,920	2,060	1,280
8	2,180	2,440	2,680	2,433	1,880	1,640
9	1,840	2,100	1,560	1,833	1,800	960
10	1,500	1,600	1,200	1,433	1,680	820
11	2,050	2,420	2,300	2,257	1,500	2,260
12	1,580	2,140	2,400	2,040	1,880	1,620
13	1,590	1,580	1,340	1,503	1,640	1,080
14	3,080	2,080	2,300	2,487	2,160	1,900
15	2,250	2,080	2,160	2,163	1,840	2,580
16	1,610	1,420	1,780	1,603	1,900	1,140
17	2,200	2,420	2,200	2,280	1,840	1,120
18	2,100	2,520	2,780	2,467	1,680	1,520
19	1,270	1,340	1,560	1,390	1,440	900
20	1,620	2,280	2,520	2,140	1,420	1,380
21	1,960	2,260	2,800	2,340	1,380	1,580
22	1,540	1,820	1,900	1,753	1,480	1,260
23	2,350	2,320	3,800	2,823	1,840	1,980
24	1,980	2,100	3,820	2,633	1,740	1,800
25	1,500	2,220	1,520	1,747	1,160	960
26	1,910	2,660	3,740	2,770	1,740	1,760
27	1,820	2,520	2,580	2,307	1,800	1,420
28	1,560	2,200	1,340	1,700	1,860	*1,140
29	2,120	3,180	2,600	2,633	2,340	2,040
30	2,500	3,100	2,780	2,793	2,600	1,300
31	1,380	2,080	1,280	1,580	1,940	960
32	2,260	2,880	2,360	2,500	2,340	1,680
33	2,160	2,960	2,700	2,607	2,200	1,660
34	1,180	1,460	1,260	1,243	1,540	1,020
35	1,750	1,980	2,780	2,170	1,640	1,760
36	1,880	2,700	2,680	2,420	1,540	1,200
37	*1,130	1,460	1,580	1,390	1,300	....
38	2,120	2,400	2,780	2,433	1,800	....
39	1,220	2,400	2,460	2,027	1,300	....
40	1,130	1,480	1,440	1,350	1,320	....

TABLE LI: YIELDS OF CLOVER IN ROTATION WITH WHEAT AND POTATOES—WOOSTER.

Plot	Pounds of hay per acre				
	1896	1897	1898	1899	Av'age
1	5,250	5,350	3,300	2,896	4,199
2	5,000	4,750	4,150	3,088	4,247
3	4,150	4,750	3,950	2,796	3,911
4	4,400	4,500	3,900	2,632	3,858
5	5,000	4,700	3,700	2,935	4,048
6	5,430	4,420	3,500	3,896	4,311
7	5,000	4,180	3,350	3,232	3,940
8	4,850	4,250	3,400	4,059	4,140
9	5,030	4,450	3,680	4,030	4,297
10	4,750	4,320	3,860	2,560	3,872
11	4,450	4,430	3,490	3,650	4,005
12	5,000	4,790	3,500	4,117	4,352
13	4,200	4,430	3,730	3,136	3,874
14	4,350	4,620	3,680	4,132	4,195
15	4,880	4,350	3,520	4,000	4,187
16	3,430	4,600	3,520	2,528	3,519
17	4,660	4,550	3,380	3,183	3,943
18	4,950	5,120	3,620	3,694	4,346
19	3,450	3,900	3,480	2,512	3,335
20	4,600	4,430	3,730	3,694	4,113
21	4,200	3,750	3,140	4,132	3,805
22	3,450	3,920	3,100	3,264	3,433
23	3,380	3,800	3,300	3,402	3,470
24	3,450	4,440	3,300	2,905	3,524
25	2,800	4,820	3,160	2,496	3,319
26	3,050	4,390	3,600	3,110	3,537
27	3,480	4,210	3,380	3,051	3,530
28	3,200	4,470	3,280	2,448	3,349
29	4,650	4,460	3,420	4,263	4,198
30	4,600	3,880	3,350	3,854	3,923
31	2,820	4,240	3,400	2,144	3,151
32	....	4,780	3,700	3,694	3,697
33	....	4,620	3,800	2,394	3,097
34	....	4,820	3,550	1,984	2,767

TABLE LII: YIELDS OF POTATOES IN 3-YEAR ROTATION — WOOSTER.

Plot	Bushels per acre (1 bu.—60 lbs.)						
	1894	1895*	1896*	1897	1898	1899*	Average
1	72.00	175.69	161.96	209.6	158.58	191.34	161.53
2	102.91	206.04	200.20	210.6	167.83	207.00	182.42
3	98.34	165.75	202.90	203.9	171.33	207.23	174.91
4	100.83	159.52	206.00	182.7	158.58	202.99	168.44
5	108.67	143.30	235.83	192.7	155.18	202.63	173.05
6	128.34	172.02	259.09	227.0	161.79	215.96	194.02
7	112.17	120.00	204.00	190.5	144.00	201.48	162.03
8	138.67	162.16	218.28	218.2	169.58	222.71	188.26
9	122.34	142.36	221.00	216.2	165.25	210.24	179.56
10	99.83	121.36	216.44	191.7	151.75	202.32	163.89
11	124.17	158.35	228.48	219.2	160.58	201.90	182.11
12	122.33	199.08	226.44	221.3	167.46	200.52	189.51
13	95.10	122.40	214.20	174.8	138.46	202.14	157.85
14	142.05	185.84	251.00	216.8	159.83	210.37	194.32
15	149.50	202.64	240.72	233.3	143.29	214.43	197.32
16	79.67	141.48	209.10	166.6	134.04	210.59	156.90
17	85.50	131.72	184.00	177.3	156.75	209.90	157.52
18	93.50	121.52	177.88	178.6	165.25	210.70	157.91
19	101.50	118.72	176.44	167.1	147.25	201.13	152.03
20	142.22	168.09	218.88	216.3	168.71	208.52	187.12
21	150.05	153.60	208.08	217.8	150.00	209.92	181.57
22	118.33	114.24	187.88	178.0	134.12	203.29	155.98
23	150.33	170.13	218.28	218.0	155.79	200.53	185.51
24	151.50	164.00	189.72	203.0	159.17	198.85	177.71
25	112.33	102.20	178.00	175.3	147.04	182.85	149.62
26	136.50	127.28	....	198.7	155.92	192.78	*164.88
27	132.67	138.72	213.04	206.5	163.62	194.41	174.83
28	104.83	100.96	198.88	184.5	151.96	186.41	154.59
29	138.50	111.76	198.86	213.8	171.79	198.50	172.20
30	125.33	133.80	255.00	238.5	166.21	206.91	187.62
31	112.17	88.72	185.00	186.5	150.71	173.76	149.48
32	....	80.96	174.80	174.2	174.17	202.50	....
33	....	....	197.86	164.0	151.33	198.19	....
34	....	....	186.00	148.3	143.54	183.53	....

TABLE LIII: YIELDS OF WHEAT IN ROTATION WITH POTATOES AND CLOVER — WOOSTER.

Plot	Bushels of grain per acre (1 bu. = 60 lbs.)						Pounds of straw per acre					
	1895	1896	1897	1898	1899	Av'ge	1895	1896	1897	1898	1899	Av'ge
1	8.67	16.67	33.67	23.54	27.58	22.08	780	1,340	3,530	2,407	3,690	2,287
2	15.92	17.58	35.25	26.58	29.75	25.07	1,195	1,780	3,685	2,555	3,565	2,556
3	9.17	11.50	38.00	24.08	31.00	22.75	700	1,030	3,380	2,775	2,790	2,135
4	7.83	6.58	35.50	20.37	29.00	19.86	880	535	3,570	2,017	2,960	1,992
5	10.17	8.79	38.50	23.21	30.50	22.23	390	972	4,210	2,607	3,170	2,270
6	13.58	10.58	39.25	34.92	34.67	27.60	1,335	915	4,245	3,655	3,620	2,754
7	8.91	5.83	34.17	25.25	26.75	20.08	365	480	3,840	2,505	2,875	2,013
8	20.17	10.29	39.83	34.25	34.33	27.77	1,440	872	3,780	2,925	3,580	2,519
9	12.00	11.75	45.67	32.42	33.92	27.15	930	1,005	4,160	3,015	3,215	2,465
10	8.33	6.87	36.17	23.37	29.50	20.85	800	667	3,710	1,657	2,890	2,005
11	16.25	15.30	45.00	33.25	39.00	29.74	1,225	1,187	4,400	3,135	4,040	2,797
12	19.75	13.54	48.00	35.08	39.25	31.12	1,665	1,217	4,820	3,135	4,295	3,026
13	8.00	7.45	37.33	24.92	23.75	21.29	670	712	3,810	2,105	2,925	2,044
14	13.17	13.50	47.75	37.25	38.67	32.07	1,360	1,340	4,685	3,815	4,110	3,062
15	13.67	14.33	44.00	37.42	35.67	30.02	1,280	1,040	4,210	3,405	4,000	2,787
16	7.75	7.21	37.50	23.08	27.33	20.57	685	577	3,700	2,325	2,790	2,015
17	8.92	10.25	37.83	25.58	30.83	22.68	715	865	3,730	2,545	3,220	2,215
18	9.75	11.83	34.33	27.92	33.08	23.38	765	960	3,290	2,645	3,585	2,249
19	6.08	6.16	32.92	20.21	25.88	18.24	685	410	3,215	2,087	2,520	1,773
20	9.00	9.12	33.58	30.08	34.08	23.17	660	762	3,045	3,045	3,595	2,221
21	16.67	10.62	36.83	31.75	35.50	26.27	1,250	852	3,390	2,696	3,850	2,407
22	7.59	4.79	31.17	22.71	22.00	17.68	700	452	2,980	2,187	2,040	1,672
23	13.67	8.83	35.50	35.92	36.00	26.58	1,100	820	3,330	3,195	4,140	2,517
24	16.50	9.16	38.67	34.92	35.17	26.88	960	660	3,730	3,155	4,010	2,503
25	6.67	6.91	32.50	20.87	23.17	18.02	550	685	3,100	1,897	2,290	1,704
26	14.25	10.29	43.92	35.58	37.25	28.26	1,045	1,062	4,465	3,465	3,965	2,804
27	14.50	12.41	43.42	36.58	36.67	28.72	860	1,085	4,415	3,455	4,020	2,771
28	7.00	6.25	34.50	24.92	23.00	19.18	830	745	3,180	2,455	2,370	1,906
29	17.92	11.87	41.17	38.25	39.50	29.74	1,275	1,187	4,030	3,875	4,330	2,939
30	9.92	5.66	34.67	35.03	30.50	23.17	805	580	3,170	3,175	3,120	2,170
31	5.92	*6.00	33.67	24.58	24.25	18.88	545	*600	3,130	2,375	2,495	1,829
32	......	......	39.17	32.25	34.58	35.33	......	......	3,470	2,865	3,845	3,393
33	......	......	39.17	32.92	35.83	35.97	......	......	3,550	2,775	3,900	3,408
34	......	......	30.83	22.04	23.17	25.35	......	......	2,850	1,977	2,410	2,412

TABLE LIV. YIELDS OF WHEAT IN ROTATION WITH POTATOES AND CLOVER — STRONGSVILLE.

Plot	Bushels of grain per acre (1 bu. = 60 lbs.)				Pounds of straw per acre			
	1897	1898	1899	Av'ge	1897	1898	1899	Av'ge
1	26.42	*2.10	12.17	13.56	2,235	*253	1,270	1,253
2	31.50	11.08	19.50	20.69	3,310	1,045	1,870	2,075
3	32.33	1.75	10.83	14.97	2,660	205	1,070	1,312
4	19.33	1.64	*7.55	9.51	1,520	182	*705	802
5	19.83	0.67	13.50	11.33	2,010	60	1,270	1,113
6	34.50	10.00	30.83	25.11	3,130	944	2,680	2,251
7	20.58	0.47	9.00	10.02	1,725	52	820	866
8	34.58	8.25	28.83	23.89	3,205	710	2,390	2,102
9	22.33	1.85	11.33	11.84	1,860	170	1,180	1,070
10	17.17	1.23	8.00	8.80	1,570	136	760	822
11	39.33	8.75	30.83	36.30	3,640	605	3,110	2,452
12	41.67	10.08	26.00	25.92	4,067	990	2,380	2,479
13	18.33	0.94	8.83	9.37	1,700	104	850	885
14	42.67	11.50	27.67	27.28	4,280	1,000	2,380	2,553
15	31.83	6.50	31.00	23.11	2,770	590	3,080	2,147
16	16.25	1.34	6.67	8.09	1,545	149	700	798
17	20.33	4.50	13.00	12.61	1,700	370	1,160	1,077
18	28.68	10.17	12.33	17.06	2,598	1,050	1,060	1,569
19	20.83	2.46	5.33	9.54	2,070	273	600	981
20	26.33	5.08	10.00	13.80	2,340	475	680	1,165
21	39.50	5.92	26.50	23.97	3,430	625	2,210	2,088
22	20.00	3.01	6.67	9.89	1,850	334	600	928
23	34.00	7.67	27.33	23.00	3,000	640	2,420	2,020
24	35.84	10.58	18.67	21.70	3,850	800	1,580	2,077
25	19.75	0.47	8.00	9.41	1,855	52	600	836
26	39.79	12.08	29.50	27.12	3,912	1,115	2,550	2,526
27	36.83	8.50	23.33	22.89	3,396	750	2,080	2,075
28	21.07	1.72	5.50	9.43	2,061	193	300	851
29	40.75	18.33	27.50	28.86	3,855	1,410	2,350	2,538
30	19.36	6.42	12.33	12.69	2,675	475	1,040	1,397
31	20.67	5.32	7.50	11.16	1,680	591	650	974
32	31.80	16.67	26.67	25.05	2,887	1,430	2,340	2,219
33	34.17	18.75	27.33	26.75	2,990	1,525	2,640	2,365
34	20.77	3.74	5.33	9.95	1,915	416	520	950
35	39.83	12.75	28.33	27.30	3,810	1,195	3,040	2,682
36	34.95	22.33	24.08	27.12	3,860	1,860	2,215	2,645
37	16.50	2.87	7.55	8.97	1,410	316	705	810
38	17.35	10.50	....	13.92	1,755	1,000	....	1,377

TABLE LV: YIELDS OF CORN IN CONTINUOUS CULTURE — COLUMBUS.

Plot	Bushels of ear-corn per acre. (1 bu.—70 lbs.)											
	1888*	1889*	1890*	1891	1892	1893	1894	1895	1896	1897	1898	Average
1	86.0	64.6	51.3	59.4	66.3	35.6	38.60	16.27	44.93	31.57	23.79	46.85
2	83.0	65.0	49.4	61.1	61.4	38.3	46.35	20.32	49.86	34.43	18.07	47.93
3	89.4	60.0	50.3	61.7	65.7	40.7	52.39	22.98	52.50	39.71	34.00	51.76
4	94.2	68.3	51.6	58.3	63.3	38.2	48.57	25.68	52.29	38.00	20.71	50.83
5	91.4	67.7	50.4	68.1	74.9	37.6	49.57	27.62	53.79	48.57	32.00	54.70
6	96.8	68.9	50.3	69.75	78.57	38.86	49.25	28.65	47.57	50.29	23.43	54.31
7	93.0	59.3	44.1	58.2	64.7	37.0	47.07	28.13	49.36	39.86	20.43	49.20
8	89.5	63.7	48.4	54.2	74.0	40.0	51.60	30.48	58.57	40.86	25.71	52.46
9	93.1	67.6	53.9	68.0	76.4	40.7	53.89	29.56	54.71	41.43	26.29	55.05
10	92.1	61.1	47.4	59.4	66.0	38.3	47.10	24.60	45.57	37.29	18.86	48.88
11	85.7	71.1	50.5	69.5	76.0	41.25	51.46	30.55	56.43	43.00	29.00	54.95
12	93.7	63.9	54.1	71.6	77.4	40.2	50.78	26.43	61.00	40.71	28.29	55.28
13	90.5	67.7	48.1	59.7	68.3	42.4	44.64	24.68	48.50	33.43	16.00	49.45
14	89.2	61.4	50.3	68.2	79.9	40.2	48.89	21.82	52.00	34.71	25.93	52.06
15	88.0	57.4	45.7	65.6	69.6	42.0	46.17	25.99	58.36	39.43	31.00	51.30
16	87.4	56.7	43.6	50.4	61.4	37.0	40.17	19.92	42.71	31.86	15.86	44.27
17	89.2	57.3	47.8	67.1	76.1	40.4	48.14	21.78	53.43	37.86	23.43	51.14
18	89.4	61.0	47.5	63.2	75.0	38.2	44.25	19.09	55.00	44.57	22.43	50.88
19	78.6	55.4	39.9	52.3	64.9	38.7	34.21	16.82	47.00	30.71	15.71	43.11
20	98.9	66.4	45.1	62.7	70.3	39.8	40.60	19.13	47.86	44.43	27.71	50.72
21	105.2	72.6	46.2	70.2	73.7	42.4	45.89	18.61	47.14	35.14	30.57	53.42
22	100.0	61.8	47.0	63.4	68.6	41.7	41.68	14.40	43.71	30.86	20.14	48.44

TABLE LV: YIELDS OF CORN IN CONTINUOUS CULTURE — COLUMBUS — Continued.

Plot	Pounds of stover per acre											
	1888*	1889*	1890*	1891	1892	1893	1894	1895	1896	1897	1898	Average
1	7,600	3,472	2,436	3,640	3,420	2,050	1,550	1,111	2,200	1,500	1,200	2,744
2	6,195	3,276	2,514	3,520	3,390	2,225	2,050	1,833	2,000	1,500	850	2,668
3	7,255	3,390	3,246	3,800	4,500	2,530	2,550	1,889	2,650	1,700	1,000	3,142
4	6,195	3,564	2,503	3,500	4,070	2,225	1,950	1,778	2,250	1,650	650	2,758
5	8,256	3,788	2,932	4,260	4,950	2,475	2,550	1,778	2,650	2,100	2,050	3,344
6	7,171	3,604	2,790	4,350	5,300	2,550	2,150	2,611	2,200	2,000	1,100	3,257
7	6,689	3,441	2,480	3,570	4,100	2,225	1,850	1,833	2,100	1,800	900	2,817
8	6,661	3,762	2,780	3,930	4,720	2,550	2,450	2,167	3,200	2,500	1,100	3,256
9	7,805	4,101	3,040	4,020	5,210	2,610	2,200	1,944	1,800	2,800	1,000	3,321
10	7,271	3,774	2,280	3,410	3,850	2,240	1,900	1,556	2,300	1,500	900	2,816
11	6,959	3,488	2,966	4,190	4,930	2,750	2,650	2,111	2,650	2,500	1,300	3,318
12	6,456	4,028	2,857	4,200	5,350	2,900	2,500	2,056	2,450	1,700	1,300	3,254
13	7,260	3,675	2,465	3,670	3,930	2,800	2,100	1,844	2,200	1,500	800	2,840
14	7,087	3,660	3,141	4,040	5,400	2,800	2,200	1,833	2,980	2,000	1,000	3,286
15	7,475	3,270	3,276	[1]	4,850	2,500	2,500	2,056	2,320	3,000	1,100	3,235
16	5,606	2,743	2,352	2,980	3,330	2,050	1,700	1,778	2,080	1,500	700	2,438
17	7,235	3,780	2,781	3,900	4,660	2,275	2,500	1,889	2,650	1,700	1,000	3,125
18	6,670	3,392	2,903	3,720	4,700	2,525	1,800	1,722	2,550	2,450	900	3,030
19	6,538	2,968	2,405	2,970	3,500	1,775	1,700	1,889	2,320	1,600	800	2,542
20	5,866	3,519	2,802	3,880	3,930	2,425	1,800	1,889	2,100	1,950	1,000	2,833
21	7,573	3,830	3,304	3,840	4,950	2,425	2,000	1,278	2,300	1,580	1,100	3,107
22	6,601	3,103	2,906	2,920	3,550	2,075	1,700	1,722	2,200	1,520	900	2,654

[1] Stalks burned by trespassers.

TABLE LVI. YIELDS OF CORN IN CONTINUOUS CULTURE — EAST LIVERPOOL.

Plot	Bushels of ear-corn per acre. (1 bu.=70 lbs.)											
	1888*	1889*	1890*	1891*	1892*	1893	1894	1895	1896*	1897	1898	Av'ge
1	35.49	52.98	20.36	21.29	16.00	5.74	....	24.86	30.44	....	8.71	19.67
2	35.89	56.42	18.28	22.37	15.07	4.14	....	26.57	27.91	....	8.29	19.60
3	39.40	56.17	19.52	27.26	18.1	5.87	....	30.71	31.25	....	8.43	21.52
4	43.67	57.90	21.77	30.74	21.3	6.73	....	25.86	32.21	....	7.29	22.50
5	70.83	58.50	30.19	38.19	26.5	5.43	....	36.14	29.45	....	14.86	28.19
6	90.03	62.23	30.13	37.51	23.8	6.71	....	42.86	33.05	....	24.71	31.91
7	70.64	65.81	22.79	34.10	21.7	8.14	....	28.43	29.93	....	11.57	26.65
8	70.63	62.83	14.89	23.69	15.9	7.30	....	26.57	30.22	....	17.71	24.52
9	90.45	67.04	31.68	39.04	26.5	9.57	....	38.57	34.73	....	26.00	33.05
10	70.24	62.23	23.51	29.31	22.7	9.43	....	28.86	31.06	....	15.29	26.60
11	74.77	66.13	24.90	31.86	24.8	9.29	....	51.71	43.54	....	36.14	32.97
12	61.79	73.80	30.60	28.50	22.7	6.86	....	54.71	43.00	....	35.43	32.49
13	60.78	57.81	23.60	29.07	19.1	7.86	....	33.14	27.88	....	12.86	24.69
14	60.05	29.92	20.54	23.48	15.4	6.29	....	29.71	30.00	....	11.29	23.33

Plot	Pounds of stover per acre.											
	1888*	1889*	1890*	1891*	1892*	1893	1894	1895	1896*	1897	1898	Av'ge
1	4,520	2,797	1,914	2,170	2,285	1,200	1,630	2,700	1,430	130	720	1,951
2	4,640	2,778	2,064	2,592	2,175	1,140	1,330	2,780	1,098	146	600	1,940
3	5,050	3,001	2,125	2,934	2,282	1,320	1,300	2,950	1,287	158	640	2,095
4	4,770	2,987	1,627	2,321	2,371	1,450	1,780	2,860	1,224	162	590	2,007
5	5,800	3,030	2,585	2,868	2,581	1,220	1,190	2,980	1,770	212	960	2,288
6	6,030	3,167	2,555	3,180	2,406	1,520	1,410	3,100	2,608	268	1,560	2,528
7	4,580	3,280	1,898	2,699	2,344	1,550	1,740	2,970	1,855	198	750	2,169
8	5,390	3,502	2,417	3,833	2,158	1,240	1,020	2,700	1,623	262	1,110	2,295
9	6,590	3,549	2,762	3,192	2,607	1,600	1,190	3,150	2,734	270	1,600	2,659
10	4,960	3,188	2,022	2,770	2,397	1,700	1,700	3,100	2,058	202	1,050	2,286
11	6,500	3,346	2,255	3,188	2,538	1,620	1,400	3,800	3,969	376	2,400	2,854
12	5,140	3,757	2,596	3,828	2,474	1,570	1,450	4,090	4,011	350	2,600	2,890
13	5,590	3,082	1,428	2,844	2,261	1,630	1,400	2,700	2,781	176	1,020	2,255
14	5,810	3,028	1,520	2,547	2,080	1,480	1,020	2,620	2,112	182	880	2,115

TABLE LVII: YIELDS OF OATS IN CONTINUOUS CULTURE—COLUMBUS.

Plot.	Bushels of grain per acre (1 bu.=32 lbs.)									
	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	Av.
1	44.2	16.0	......	......	......	29.41	24.14	22.34	......	......	......
2	46.9	19.4	46.6	29.4	......	33.94	23.28	25.47	28.12	20.78	......
3	59.5	19.7	45.9	32.5	33.9	......	28.28	27.50	33.12	22.50	......
4	48.2	16.0	40.2	28.8	29.8	34.38	22.65	27.03	30.62	20.00	29.77
5	47.2	21.1	45.6	32.7	39.2	36.87	27.18	35.94	33.75	23.12	34.27
6	48.4	22.3	51.2	32.2	37.6	38.28	30.31	42.03	42.50	26.87	37.17
7	45.0	19.7	40.6	24.3	32.9	31.56	23.59	25.90	29.07	18.44	29.11
8	45.0	21.6	46.6	32.2	32.7	35.31	28.60	29.38	32.19	24.06	32.76
9	48.4	23.7	46.6	40.3	38.6	39.06	31.87	40.00	39.69	21.87	37.01
10	47.5	18.4	45.6	34.4	36.1	35.40	25.00	26.41	30.61	21.87	32.18
11	52.9	24.7	50.9	40.9	43.9	35.23	32.81	34.69	44.37	26.72	38.71
12	47.8	25.3	52.3	43.1	44.5	38.75	35.15	45.23	44.84	28.12	40.51
13	46.8	15.2	43.4	43.0	43.6	35.16	24.68	24.69	31.72	22.19	33.04
14	46.0	20.8	48.4	48.3	46.2	38.83	32.92	41.81	46.25	25.47	38.90
15	51.8	23.9	49.4	40.1	38.7	39.45	29.84	38.36	46.72	25.00	38.38
16	36.5	19.2	46.6	37.5	32.0	33.36	23.60	22.42	31.72	18.28	......
17	47.3	21.6	49.7	41.1	......	39.58	30.15	......	43.44	25.47	......
18	45.7	22.8	51.6	43.6	......	35.94	26.09	......	46.25	24.84	......
19	37.9	14.5	44.7	36.4	......	33.59	......	29.84	31.25	20.94	......
20	42.8	19.1	50.3	36.9	30.8	39.14	......	32.19	45.62	26.72	......
21	50.6	14.6	46.7	25.8	33.3	36.95	......	29.53	40.94	23.28	......
22	46.1	18.4	......	......	28.1	35.39	......	22.50	35.00	16.88	......

TABLE LVII: YIELDS OF OATS IN CONTINUOUS CULTURE — COLUMBUS — Continued.

Plot	Pounds of straw per acre										
	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	Av.
1	3,180	1,900	....	....	....	1,287	1,027	2,000	....	....	......
2	3,520	2,370	3,310	2,960	....	1,502	1,055	2,085	1,650	1,185	......
3	4,220	2,270	2,680	3,100	1,365	....	1,045	2,720	....	1,330	......
4	3,800	1,980	2,465	2,780	1,125	1,300	925	2,685	1,320	960	1,934
5	3,980	2,680	2,540	3,155	1,395	1,370	1,130	3,425	2,170	1,510	2,335
6	4,068	2,900	2,160	3,020	1,405	1,875	1,330	3,655	1,690	1,820	2,392
7	3,640	2,120	2,400	2,472	1,145	1,390	1,045	2,120	1,520	1,010	1,886
8	3,660	2,580	2,910	3,170	1,205	1,120	985	3,010	1,220	1,580	2,144
9	4,040	3,070	2,810	2,960	1,395	1,700	1,280	4,570	1,680	1,110	2,461
10	3,960	2,600	2,640	2,950	1,095	1,215	1,009	2,455	1,230	1,000	2,014
11	4,400	3,210	2,620	2,940	1,575	1,972	1,150	4,340	2,480	1,915	2,660
12	4,300	3,320	2,875	3,020	1,875	2,110	1,475	5,052	2,715	2,030	2,877
13	3,820	2,670	2,560	3,125	1,355	1,475	910	2,560	1,435	1,260	2,117
14	3,880	2,930	2,550	3,665	1,752	2,107	1,515	6,012	2,720	2,065	2,922
15	4,060	3,270	2,670	2,965	1,370	2,037	1,345	4,172	2,405	1,850	2,614
16	3,200	2,100	2,360	2,550	1,195	1,333	1,045	2,832	1,185	815	1,861
17	3,800	2,910	2,110	3,435	....	2,035	1,205	....	2,060	1,685	......
18	3,500	3,120	2,200	3,205	....	1,750	1,365	....	2,120	1,685	......
19	3,060	1,950	1,970	3,285	....	1,875	....	3,145	1,300	1,110	......
20	3,140	2,650	2,540	3,420	1,615	1,797	....	3,920	2,140	1,695	......
21	4,100	2,470	2,215	3,675	1,935	1,917	....	4,030	1,890	1,755	......
22	3,890	2,700	....	3,260	1,080	1,667	....	3,455	1,530	1,210	......

TABLE LVIII: YIELDS OF WHEAT IN CONTINUOUS CULTURE — COLUMBUS.

Plot.	Bushels of grain per acre. (1 bu.=60 lbs.)										
	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899
1	50.5	31.9	31.8	26.2	31.1	17.25	2.96	....	41.16	20.83	16.17
2	50.2	35.6	29.3	31.2	35.16	19.08	8.91	....	39.33	23.75	23.04
3	47.5	32.1	30.2	28.2	27.7	18.92	2.21	....	39.00	20.41	14.12
4	40.8	31.8	32.0	27.2	24.5	17.58	1.83	....	40.16	19.83	12.17
5	40.0	36.5	33.7	27.9	31.6	18.08	1.83	....	40.00	17.21	11.50
6	40.8	38.6	31.2	28.9	33.5	18.71	7.25	....	37.16	23.33	21.37
7	47.5	33.0	35.3	28.6	26.8	17.62	2.04	....	40.33	21.58	14.83
8	41.6	36.4	20.5	30.2	26.0	21.87	10.16	....	38.16	28.08	25.71
9	45.6	26.8	33.4	29.1	35.4	22.62	2.75	....	41.33	22.41	16.42
10	44.0	32.4	31.2	28.1	27.7	16.42	1.91	....	39.33	19.83	13.92
11	49.5	36.9	28.8	29.1	38.6	23.75	12.41	....	37.50	24.62	24.42
12	49.3	35.7	29.7	29.2	42.7	26.71	9.75	....	40.67	24.16	25.42
13	44.2	29.9	31.5	26.8	27.5	17.58	1.66	....	37.67	18.71	17.42
14	47.0	34.9	28.8	29.2	39.7	25.58	11.83	....	39.00	25.16	23.83
15	47.0	33.8	20.8	30.4	34.8	21.50	10.50	....	35.67	22.75	21.79
16	37.8	32.4	30.8	27.8	25.2	15.83	1.62	....	38.16	16.37	11.83
17	40.0	37.4	33.2	31.1	32.6	19.92	8.83	....	37.00	21.08	16.50
18	39.3	37.3	31.7	31.6	35.2	20.96	9.75	....	37.16	26.41	19.29
19	40.5	31.0	31.5	25.4	22.8	14.54	1.25	....	38.00	22.17	12.58
20	44.5	34.7	27.3	25.4	37.3	25.29	12.54	....	35.00	31.66	25.08
21	38.7	33.9	34.7	27.5	35.5	17.54	10.75	....	36.67	21.41	14.08
22	36.7	26.5	27.1	22.2	24.7	13.83	1.75	....	37.67	18.87	10.54
23	....	27.4	....	....	23.91	15.83	1.37	....	36.00	18.71	8.87
24	....	24.6	....	....	32.75	21.25	5.33	....	32.33	22.25	14.17

TABLE LVIII: YIELDS OF WHEAT IN CONTINUOUS CULTURE — COLUMBUS. Continued.

Plot.	Pounds of straw per acre										
	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899
1	4,070	3,602	4,540	3,015	2,496	1,665	422	....	4,080	1,960	1,390
2	4,208	3,885	4,995	4,265	3,275	1,655	670	....	3,840	2,155	2,497
3	3,850	3,062	3,740	3,190	2,175	1,365	267	....	3,610	1,675	1,152
4	3,692	3,282	3,980	2,650	1,490	1,945	160	....	3,630	1,610	910
5	3,560	3,930	3,980	2,710	2,705	1,615	390	....	4,060	1,417	910
6	3,512	4,385	5,390	3,830	2,690	2,377	765	....	3,970	1,850	1,757
7	4,050	3,340	4,230	2,870	2,090	1,642	277	....	3,980	1,805	1,210
8	3,304	4,152	4,570	3,625	3,444	2,187	990	....	3,860	2,395	2,277
9	4,504	3,852	4,395	2,990	2,975	2,442	585	....	3,920	2,055	1,275
10	3,500	3,667	3,580	2,806	2,085	1,615	135	....	3,850	1,510	1,085
11	4,270	4,725	5,675	4,390	3,965	3,075	1,105	....	4,190	2,222	2,215
12	4,262	4,835	5,[illegible]	4,269	3,540	3,597	1,085	....	4,170	2,050	2,435
13	3,548	3,[illegible]	3,719	2,[illegible]	2,159	1,625	400	....	3,690	1,627	1,575
14	3,020	4,592	5,820	4,235	3,515	2,985	1,190	....	3,340	2,120	2,770
15	3,920	3,720	4,660	3,[illegible]	3,310	2,810	1,220	....	3,480	2,085	2,128
16	3,632	3,307	3,200	2,715	1,665	1,550	852	....	3,510	1,317	980
17	3,460	4,175	4,880	3,720	2,845	2,505	720	....	3,680	1,885	1,410
18	3,542	4,812	4,800	3,870	2,790	2,447	1,065	....	3,970	2,315	1,582
19	3,570	2,950	3,360	2,460	1,790	1,277	245	....	3,620	2,070	1,205
20	4,090	3,850	4,810	3,110	3,490	2,682	1,517	....	3,320	3,680	2,515
21	3,618	3,775	4,670	2,835	3,154	2,397	1,105	....	3,300	2,265	1,315
22	2,640	2,677	2,775	2,050	1,965	1,370	395	....	3,640	1,697	747
23	2,960	2,635	....	....	2,015	1,550	417	....	3,540	2,497	817
24	3,154	3,130	....	....	3,315	2,235	580	....	2,810	2,265	1,690

TABLE LIX: YIELDS OF CORN IN CONTINUOUS CULTURE — WOOSTER.

Plot	Bushels of ear-corn per acre (1 bu.=70 lbs.)							Pounds of stover per acre						
	1894	1895	1896	1897	1898	1899	Average	1894	1895	1896	1897	1888	1899	Average
1	16.35	32.50	51.98	12.36	32.79	22.79	28.12	1,[illegible]	2,050	1,670	1,115	1,050	1,060	1,382
2	24.85	38.25	73.18	29.64	57.11	43.75	44.46	1,680	2,680	2,380	1,800	1,900	1,650	2,005
3	19.46	35.98	67.96	22.82	48.11	36.89	38.53	1,450	2,100	2,000	1,640	1,500	1,520	1,728
4	20.46	31.93	52.18	11.46	28.29	19.11	27.24	1,310	2,100	1,620	1,120	1,030	1,040	1,370
5	19.64	39.36	61.86	19.64	41.68	29.29	35.24	1,470	2,290	1,850	1,440	1,300	1,340	1,615
6	23.07	47.50	68.82	25.64	50.61	36.14	41.96	1,580	2,680	2,070	1,680	1,730	1,620	1,885
7	17.82	26.71	46.61	8.61	25.89	17.64	24.21	1,190	1,880	1,580	950	920	1,080	1,258
8	22.21	36.43	74.36	27.25	61.89	46.32	44.74	1,480	2,270	2,340	1,950	2,000	1,770	1,[illegible]
9	17.71	34.68	71.89	28.14	61.39	43.29	42.85	1,300	2,040	2,310	1,750	1,950	1,670	1,837
10	11.57	21.96	42.39	7.46	23.86	12.46	19.94	1,150	1,540	1,370	860	980	820	1,112

TABLE LX: YIELDS OF OATS IN CONTINUOUS CULTURE — WOOSTER.

Plot	Bushels of grain per acre (1 bu.=32 lbs.)							Pounds of straw per acre						
	1894	1895	1896	1897	1898	1899	Average	1894	1895	1896	1897	1898	1899	Average
1	24.84	33.90	22.19	27.81	25.62	24.06	26.40	855	1,015	880	810	900	650	852
2	32.34	40.78	44.37	51.25	42.34	46.25	42.89	1,615	1,105	2,110	1,560	2,095	1,720	1,701
3	29.84	39.06	39.22	44.68	40.93	44.69	39.74	1,145	1,240	1,815	1,310	1,840	1,440	1,465
4	26.41	33.67	24.06	31.56	27.66	26.41	28.29	1,005	1,237	1,200	800	1,055	785	1,014
5	26.41	33.98	26.41	34.06	33.28	31.87	31.00	905	1,062	1,155	880	1,155	900	1,011
6	30.16	37.65	30.00	39.37	36.87	40.62	35.78	1,335	1,045	1,270	1,120	1,560	1,470	1,300
7	22.11	32.73	24.69	31.25	28.91	29.37	28.18	1,192	1,202	1,190	800	1,165	840	1,065
8	37.19	45.31	54.37	55.94	50.94	64.06	51.30	2,010	1,350	2,700	1,760	2,610	2,670	2,183
9	37.97	48.90	52.19	52.50	48.12	60.00	49.11	1,735	1,345	2,650	1,600	2,580	2,480	2,065
10	28.28	33.28	24.22	31.25	29.37	29.06	29.24	1,295	1,135	1,185	850	1,210	970	1,099

TABLE LXI: YIELDS OF WHEAT IN CONTINUOUS CULTURE — WOOSTER.

Plot	Bushels of grain per acre (1 bu.=60 lbs.)							Pounds of straw per acre						
	1894	1895	1896	1897	1898	1899	Average	1894	1895	1896	1897	1898	1899	Average
1	13.71	5.92	1.12	20.25	11.79	2.83	9.27	1,177	645	92	3,465	1,292	380	1,175
2	19.00	14.83	6.08	32.83	26.17	18.25	19.53	2,010	1,210	775	4,400	2,630	2,075	2,183
3	15.21	11.42	3.08	31.00	20.96	10.67	15.39	1,337	965	315	3,840	2,143	1,190	1,632
4	13.21	4.92	1.29	20.00	11.87	3.17	9.08	1,057	455	122	2,300	1,287	460	947
5	14.21	7.75	2.83	24.33	17.29	7.92	12.39	1,547	785	390	2,950	1,712	925	1,383
6	13.87	10.50	5.29	29.08	20.62	10.83	14.95	1,797	870	692	3,345	2,013	1,410	1,688
7	11.56	4.67	0.96	20.83	11.71	4.08	8.97	957	470	120	2,430	1,247	595	970
8	14.87	15.67	6.50	37.42	29.00	22.58	21.01	1,757	1,360	860	5,365	3,210	2,395	2,491
9	13.37	13.92	3.91	36.83	27.00	16.83	18.64	1,597	1,215	485	4,670	2,830	1,710	2,084
10	10.71	3.92	1.16	20.50	11.46	4.58	8.72	907	365	210	2,510	1,262	655	985

TABLE LXII: YIELDS OF CORN IN BARNYARD MANURE TEST — WOOSTER.

Plot	Bushels of ear-corn per acre (1 bu. = 70 lbs.)				Pounds of stover per acre			
	1897	1898	1899	Av.	1897	1898	1899	Av.
1	15.71	59.09	45.94	40.25	1,280	1,380	2,048	1,569
2	30.06	73.46	57.77	53.76	2,144	1,870	2,624	2,213
3	32.17	71.78	61.83	55.26	2,192	1,710	2,912	2,271
4	9.09	51.02	46.23	35.45	1,024	1,040	2,170	1,411
5	18.29	75.31	57.26	50.29	1,520	1,770	2,704	1,998
6	21.09	75.89	60.97	52.65	1,664	1,900	2,720	2,095
7	6.00	52.58	37.20	31.93	928	1,040	1,712	1,227
8	19.71	79.20	48.06	48.99	1,568	1,860	2,192	1,873
9	21.87	77.82	59.14	52.78	1,728	1,720	2,592	2,013
10	11.09	54.29	43.94	36.44	1,536	1,050	1,824	1,470
11	14.74	62.51	40.29	39.18	1,440	1,590	1,856	1,629
12	29.83	76.08	56.97	54.29	2,416	2,000	2,480	2,299
13	33.77	81.26	58.80	57.94	2,544	2,300	2,720	2,521
14	16.91	52.33	44.20	37.81	1,600	1,050	1,872	1,507
15	26.91	74.46	54.00	51.79	2,080	1,770	2,368	2,073
16	28.00	70.18	60.20	52.79	2,128	1,700	2,736	2,188
17	10.84	53.20	48.51	37.85	1,216	1,140	2,240	1,532
18	19.66	57.88	55.66	44.28	1,632	1,220	2,592	1,815
19	22.17	58.11	54.97	45.08	1,776	1,250	2,176	1,736
20	18.88	53.26	47.81	38.15	1,312	1,100	1,952	1,455

TABLE LXIII. YIELDS OF WHEAT IN BARNYARD MANURE TESTS — WOOSTER.

Plot	Bushels of grain per acre (1 bu. = 60 lbs.)			Pounds of straw per acre		
	1898	1899	Average	1898	1899	Average
1	16.87	6.53	11.70	1,707	632	1,169
2	27.80	11.73	19.76	2,971	1,104	2,037
3	29.93	14.13	22.03	3,083	1,392	2,237
4	18.20	2.67	10.43	1,788	160	974
5	26.73	12.80	19.76	2,731	1,200	1,965
6	28.60	14.93	21.76	2,922	1,504	2,213
7	18.20	2.67	10.43	1,787	240	1,013
8	31.13	8.27	19.70	3,412	752	2,081
9	31.80	9.87	20.83	3,227	1,200	2,213
10	21.53	2.93	12.23	1,972	144	1,058
11	17.67	8.80	13.23	1,739	880	1,309
12	26.47	12.80	19.63	2,811	1,344	2,077
13	28.33	13.33	20.83	2,779	1,280	2,029
14	17.12	1.73	9.42	1,691	120	905
15	24.60	7.60	16.10	2,779	664	1,721
16	23.53	6.67	15.10	2,571	672	1,621
17	15.27	2.80	9.03	1,547	264	905
18	20.60	3.33	11.96	2,219	344	1,281
19	22.47	5.07	13.77	2,203	368	1,285
20	16.87	3.33	10.10	1,979	280	1,129

Ohio Agricultural Experiment Station.

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INVESTIGATIONS OF PLANT DISEASES.

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BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 111. DECEMBER, 1899.

INVESTIGATIONS OF PLANT DISEASES.

A SUMMARY OF THE WORK OF THE OHIO AGRICULTURAL EXPERIMENT STATION FROM 1891 TO 1899, IN THE CONTROL OF DISEASES OF PLANTS.

By A. D. SELBY.

INTRODUCTION.

BY THE DIRECTOR.

The following summary of the work of the Ohio Agricultural Experiment Station in the control of fungous diseases of plants has been prepared at the request of a committee of the Association of American Agricultural Colleges and Experiment Stations, as a contribution to the exhibit to be made by the United States Department of Agriculture, at the Paris Exposition of 1900.

Investigations, having for their object the development of practicable methods for the control of plant diseases, were begun by this Station soon after its reorganization under the Hatch act, in 1888, and have since been steadily pursued. The period covered by these investigations has been marked in the United States, as well as elsewhere, by great strides in the science of vegetable pathology, a science which practically dates from the discovery, during the ninth decade of the nineteenth century, of the efficacy of salts of copper in controlling the parasitic fungi with which many higher plants are infested. Since this discovery was made in France it seems fitting that one of the contributions to the great exposition, with which that nation is celebrating the close of the century, should be a review of work accomplished and results attained in this field of investigation.

As the earlier publications of this Station on this subject are now out of print, it has seemed proper to give a somewhat detailed report

of the field experiments of 1891, especially as these experiments illustrate well the method of research which has been followed throughout, a method having special reference to the practical utilization, on a commercial scale, of the preventives and remedies indicated.

The more recent work has been more briefly outlined, since detailed publications are still accessible to those who may desire them; but it is hoped that even to those most familiar with the Station's work in this field the present publication may offer something of value, by presenting in a single perspective the various investigations in this very effective line of public service.

Yet another reason for offering this review at the present date may be found in the years to come. As we look back over what has been accomplished during the past decade in the demonstration of the value and practical use of fungicides, we may properly reflect that this phase of the study of parasitism has probably reached its highest point. Already there are indications that the diseases not controlled by the use of fungicides are to claim in the future a large share of attention from the vegetable pathologist. The possible roles of enzymes, or soluble ferments, in the plant itself, and of soil-infesting fungi, beyond the reach of fungicides, are being studied, and there would seem to be no more opportune time of presenting this review of what has been accomplished than just at the moment when we are beginning to look forward towards new fields of research. The demonstration of the attainments of the past and their great practical value will be the surest basis for predicting the results and value of future work along similar lines.

GENERAL PLAN AND LINES OF WORK.

Several distinct aims have always been in view; yet these admit of condensation into a single statement, namely, the profitable control of the fungous diseases of the plants cultivated in the state. To attain this end several objects have seemed to require separate recognition:—

1. To obtain a knowledge of the parasites in question.
2. To discover the best fungicides for the end sought.
3. To determine the time of most efficient application, also the number of applications required.
4. To conduct the experiments on a commercial scale.
5. To coöperate, when possible, with growers centrally located for the matter studied.
6. To first serve interests in urgent need and of largest importance.

In following out the plans just stated many and varied investigations were made at the Station itself and upon its own grounds; in several instances this work was entirely done on these grounds at Columbus and latterly at Wooster. Coöperation became necessary at times, and throughout it has been steadily pursued as a policy, since local demonstration

of the value of results within the boundaries of a well developed industry, removes all questions arising from remoteness or lack of familiarity with conditions. Likewise work on a commercial scale lends itself to expression easily understood by the commercial operator. Throughout the work, and in all this resumé, it has been the policy to reject unprofitable methods, to avoid spray mixtures of excessive cost and to abandon any feature that would not succeed on a commercial scale or admit of wider application than mere demonstration of possibility.

APPLE SCAB.

In 1891 the officers of the Station carried out one of the pioneer investigations on this destructive apple disease. The results were published in illustrated form in December of that year (Bulletin No. 9, Vol. IV, December 1891). In that publication the Botanist, Miss F. Detmers, illustrated the effects of the apple scab fungus (*Fusicladium dendriticum* (Wall.) Fckl.) upon both fruit and foliage. A portion of these cuts are again reproduced. It was thus recognized at the outset that a leaf infesting fungus and a fruit infesting fungus was to be dealt with. In the same bulletin the Station Horticulturist, Professor W. J. Green, reported the results of spraying experiments.

SPRAYING TO PREVENT APPLE SCAB (1891).

It is proper to recall that at this time no really successful commercial experiments in orchard spraying for scab had been published. These were apparently the pioneer experiments on a commercial scale and the first, or among the first, successful ones with Bordeaux mixture.*

At this time (1890–91) Taft in Michigan and Goff in Wisconsin,

* See Fairchild, D. G. "Bordeaux Mixture as a Fungicide." Bulletin No. 6, Div. of Veg. Path. U. S. Dept. Agric. 1894.

Page 43 this author states: — "In 1891 Green carried on an excellent series of experiments in the treatment of the disease, which, from its size and the carefulness with which it was carried out, make it, so far as the writer's search has revealed, the most valuable contribution to the subject yet published. The experiments of Taft and Goff with other fungicides than Bordeaux mixture seem to have yielded results that will not bear a careful comparison with those obtained by the use of this latter mixture. It can quite safely be stated that in the treatment of apple scab this mixture has proved more efficacious than any other. From the extensive nature of Green's experiment and the evidence offered by the subsequent experiments of Goff, Lodeman, Munson and Garman, as well as from the testimony of many practical horticulturalists, it may safely be affirmed, that the treatment of apple scab is successful from an economic standpoint. The increased size of the fruit from the prevention of the fungus, which has been shown by Green to be considerable, as well as the production of fair fruit, make the increased market value of the crop many times greater than the expense of treatment."

In view of all this it is a matter of remark that Lodeman in "The Spraying of Plants," 1896, makes no reference to this publication, although a summary of work in 1891 is given, pp. 108–110.

as well as many European investigators, had experimented in the treatment of apple scab; some had tried but none had succeeded with Bordeaux mixture. The following report of experiments in spraying for apple scab is largely quoted from Prof. Green's original bulletin.

"The work in spraying apples was undertaken for the purpose of investigating the following points: (1) The compounds to use to prevent the apple scab. (2) The time to make the applications. (3) The compounds best adapted to be used with Paris green and London purple. (4) Profit in spraying on a commercial scale. . . . . .

"In order to put the matter upon a commercial basis, as nearly as possible, an orchard of about thirty acres, two miles east of the Station, was selected and leased. One-third of this orchard was Newtown Pippin, a variety much subject to the scab, and the remainder was made up principally of Northern Spy, Rhode Island Greening, Baldwin, Jonathan, Westfield Seeknofurther, Smith's Cider, Bellflower and Roxbury Russet. Experiments in the same line were also carried on by the Station in Ottawa county, near Lake Erie, and in Lawrence county, on the Ohio river, by Nelson Cox, under direction of the Station. In each locality account of material and labor was kept, and notes taken when crops were harvested, in order to determine the cost of spraying and the profit when the operations are carried out on a commercial scale.

"About one thousand bushels were gathered from the trees included in the experiment near Columbus, and more than one hundred bushels were assorted and counted in note taking. In Lawrence and Ottawa counties the work was nearly as extensive, but the note taking was less elaborate.

COMPARISONS OF MIXTURES USED.

"The Newtown Pippin orchard was chosen for experiments with different mixtures, there being a sufficient number of trees to devote two rows of trees to each compound tested, and to leave five rows unsprayed. The following compounds were compared:

(A) Ammoniacal Carbonate of Copper.
(B) Modified Eau Celeste.
(C) Dilute Bordeaux Mixture.
(D) Precipitated Carbonate of Copper.
(E) Ammonia-Copper Solution.

"Seven applications were made during the season as follows: April 8, May 7 and 26, June 13 and 19, July 16. The weather was very rainy during May and June, and the applications were made more frequently than would have been done otherwise.

"The following table shows the relative efficiency of the different compounds.

"In assorting, ten bushels were taken from each plot, in such a manner as to include about an equal quantity from each tree, of as near an

average grade as possible. These were then separated into three grades, viz: first quality, free from scab; second quality, more or less scabby; third quality, very scabby or unmarketable.

TABLE I. RELATIVE EFFICIENCY OF SPRAYING COMPOUNDS.

Compound used.*	Per cent. of apples of first quality or free from scab.	Per cent. of apples of second quality or somewhat scabby.	Per cent. of apples of third quality or very scabby and unmarketable.
Ammoniacal Carbonate of Copper	5	72	23
Modified Eau Celeste	12	81	7
Dilute Bordeaux Mixture	15	74	11
Precipitated Carbonate of Copper	14	54	32
Ammonia-Copper Solution	1	50	49
Unsprayed	....	40	60

"It appears from the above exhibit that modified eau celeste, dilute Bordeaux mixture and precipitated carbonate of copper gave the best results, the latter showing the highest percent of third class, or very scabby apples. The results obtained with the three compounds are so nearly alike that the variation need not be regarded as important. Ammoniacal carbonate of copper and ammonia-copper solution fall below the others, the latter considerably so. This may be partly due to the fact that these

* The following are the directions followed for the preparations of mixtures in the above experiments. (See Bulletin Vol. IV, No. 9.)

"Ammoniacal Carbonate of Copper. — This is made by dissolving six ounces copper carbonate in two quarts of commercial aqua ammonia (more or less ammonia is required according to its strength), and diluting with fifty gallons of water. Although this did not prove to be so efficient as some other mixtures it is valuable to use late in the season on grapes, and wherever the Bordeaux would be objectionable, because of the coating it forms. Paris green or London purple should not be used in this mixture.

"Modified Eau Celeste. — Dissolve two pounds of copper sulfate in one gallon of hot water; also two and one-half pounds of carbonate of soda in the same quantity of hot water; when cool mix and add one quart of commercial aqua ammonia and dilute to thirty gallons. This compound is efficient and useful, but somewhat expensive and liable to injure the foliage of raspberries and pears. No doubt if diluted to fifty gallons it would be effective. Paris green or London purple should not be used with it.

"Dilute Bordeaux Mixture. — Dissolve four pounds of copper sulfate in two gallons of hot water; pour this into the tank or barrel and add sufficient water to cool it. Slake four pounds of quicklime, after which add water to make a paste or

compounds are more easily washed off by the rains than the three first mentioned. Possibly the ammoniacal carbonate of copper may be less effective than some of the other mixtures, but it still has a place, as will be shown in succeeding pages. The dilute Bordeaux mixture is preferable to the others for reasons that will be given further on.

"In order more fully to compare the different compounds it is necessary to consider the cost of each, nor is the cost of materials all that need be taken into account."

While in these experiments for 1891 the modified eau celeste gave slightly more favorable results than the dilute Bordeaux mixture, subsequent trials have been more favorable to the latter fungicide. The Bordeaux mixture is to be preferred by reason also of the possible combination of arsenites with it in the spraying.

"In spraying with the arsenites for the apple worm, Paris green or London purple may be used in connection with the Bordeaux mixture and the precipitated carbonate of copper, but since the latter is, of itself, liable to injure the foliage, it would hardly be advisable to add Paris green or London purple, and thus increase the danger. The combination of Paris green and Bordeaux mixture is not only harmless to the foliage, but saves the separate spraying for the apple worm. Table II gives the cost of materials and labor to spray one hundred trees for the season with each fungicide, also the cost when Paris green is added. With the Bordeaux mixture there is no extra cost in labor, but the price of the Paris green is added, as with the other compounds. The data for these estimates will be found under cost of spraying. The estimates are for four applications of fungicides and two of insecticides.

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milk of lime; pour this into the vessel containing the copper sulfate solution, straining through a brass wire sieve as it is poured in. This operation with the lime should be repeated several times so as to dissolve as much as possible of it. Usually a quantity will remain undissolved, but the amount taken being more than is actually required it is not necessary to use it all. This mixture should be stirred and diluted to fifty gallons. If carefully made this mixture gives less trouble in clogging the nozzle than the strong Bordeaux mixture commonly advised. With the Vermorel nozzle it gives no trouble whatever. This mixture ranks high in efficiency, and Paris green or London purple can be used with it. It seems to have a wider range of usefulness than any other, and is confidently recommended.

"Precipitated Carbonate of Copper.— This is the same as modified eau celeste with ammonia left out. It is efficient and useful, but apt to injure foliage, although it may be used upon apple trees with safety.

"Ammonia-Copper Solution. — Dissolve one pound of carbonate of ammonia in six quarts of boiling water; add one-half pound of copper sulfate, and after reaction has ceased dilute to thirty gallons. This was not satisfactory as it injured the foliage except upon apple trees, nor was it efficient."

TABLE II. COST OF SPRAYING WITH DIFFERENT COMPOUNDS COMPARED.

Name of fungicide	Cost of material and labor to spray one hundred apple trees with the fungicide, one season	Cost of material and labor to spray one hundred apple trees with both fungicide and insecticide, one season
Ammoniacal Carbonate of Copper	$17.30	$22.55
Modified Eau Celeste	18.50	23.75
Dilute Bordeaux Mixture	14.10	15.10
Precipitated Carbonate of Copper	15.50	20.75
Ammonia-Copper Solution	13.70	18.95

"Had the Bordeaux mixture been used of the strength commonly advised, viz: Six pounds sulfate of copper to twenty-two gallons of water, the total cost would have been more than doubled, which would make it the most costly of all. It is not known whether the stronger mixture would be more effective than that used, but of the strength employed, as has been shown, it was as effective as any other compound. Its advantages over other fungicides are therefore apparent. It is not only the cheapest fungicide, but is the best to use in combination with the arsenites, because it prevents injury to the foliage and effects a saving in labor equivalent to two sprayings.

WHAT EFFECT DOES THE APPLE SCAB HAVE UPON THE FRUIT?

"Aside from the inferior appearance of scabby fruit, the effect of the scab is to retard the growth of both foliage and fruit, hence scabby apples are smaller than those free from scab. The difference in size between apples that are affected by scab and those that are free from it is not the same with all varieties, nor with any given variety in different localities. That the difference may often be considerable is shown by some comparisons that were made between scabby Newtown Pippins and those that were free from the disease. One bushel of that variety that were free from scab was found to contain 202 apples, while the same quantity of scabby apples contained 317. The average weight per apple was 4 and 2½ ounces respectively. This comparison was between extremes, but those of the second class were, in size, far below those that were free from scab. It is no doubt true that scab may cause a diminution in size of fifty percent, but in most cases the loss is below that figure. In all cases scab hinders development but not always in proportion to the amount found on the

fruit. *With some varieties the scab does more damage to the leaves than to the fruit, the Ben Davis being a good example.* In Lawrence county, the past season, many trees of this variety *had lost nearly all their foliage because of scab, before the fruit ripened.* How much the development of the fruit was retarded cannot be estimated, but the loss was serious. Wherever scab is present at all, either upon fruit or leaves, the effect must be considerable in arresting the development of the fruit.

TO WHAT EXTENT DOES SPRAYING WITH FUNGICIDES PREVENT THE APPLE SCAB?

"A comparison of the results obtained with several varieties will throw some light upon this question. Dilute Bordeaux mixture was used upon all throughout the season, except Rome Beauty, to which it was applied twice, followed by two sprayings with modified eau celeste.

TABLE III. EFFECT OF SPRAYING, AS SHOWN BY DIFFERENT VARIETIES.

Variety	Per cent. in first class; free from scab	Per cent. in second class; somewhat scabby	Per cent. in third class; very scabby and unmarketable
Benoni, sprayed	85	8	7
Benoni, not sprayed	4	58	38
Northern Spy, sprayed	56	43	1
Northern Spy, not sprayed	7	80	13
Newtown Pippin, sprayed	15	74	11
Newtown Pippin, not sprayed	00	40	60
Rome Beauty, sprayed	93	7	00
Rome Beauty, not sprayed	1	80	19

"Figs. 3-6 present the same facts to the eye in a more striking manner. The percentages were obtained by assorting ten bushels of sprayed and ten of unsprayed apples of each variety, into three grades, viz: Those free from scab, those somewhat scabby, and those that were so scabby as to render them unmarketable. Similar results were obtained with three other varieties not here shown. The figures were made from photographs, which were taken from average specimens of the different classes. The figures show the same percentages as those given in Table III. For instance, of the sprayed Northern Spy 56 in each 100 apples were free from scab, while in the unsprayed only 7 of the same class were found, and so on for the different classes of the several varieties. One hundred apples were photographed in each case, and the number in first, second and

third classes shows the results obtained by spraying, also where no treatment was given.

"It appears from the above exhibits that the greater part of the apples of these varieties are subject to scab, and that spraying will not wholly prevent the disease. Better results could no doubt be obtained in a more favorable season, but at best the remedy is a partial one only. There is a gain with all varieties by spraying, but more with some than with others. If we make only two classes, viz.: scabby and not scabby, there was a gain of 81 percent in Benoni, 49 in Northern Spy, 15 in Newtown Pippin and 92 in Rome Beauty. This, however, does not fully represent the benefits as will appear further along, nor is it possible to state in percentages the exact extent to which scab is prevented by spraying, since there may be considerable variation in degree of scabbiness and yet not change the classification materially. It would be unsafe to attempt to generalize any further than to say that spraying varieties that are subject to scab, with fungicides, prevents the scab in a great degree.

SIZE OF APPLES AS AFFECTED BY SPRAYING WITH FUNGICIDES.

"If spraying with fungicides were a perfect remedy the gain in size of apples would be much greater than it is possible to secure by means of remedies now known. The gain with Newtown Pippin, as shown on a preceding page, would be more than 50 percent if perfect results could be secured, but in practice the gain was only 10 percent. With Benoni a gain of 20 percent was obtained; with Northern Spy 23, and Rome Beauty 36. These percentages were obtained by the countings above referred to, and represent the actual gain in size of the sprayed over the unsprayed, taking the entire number of apples in each 10 bushels, first, second and third classes. To show the effect of the scab on the size, scabby apples were compared with those not affected, but to show the effect of spraying on the size, the comparison is made between sprayed and unsprayed, each taken as a whole.

"The effect seems to be quite unlike upon different varieties, and it would be hardly possible to draw conclusions from these figures as to the probable effect upon other varieties. The good effect upon the Rome Beauty was largely due to the beneficial action of the fungicide upon the foliage, as the sprayed trees retained their leaves much longer than the unsprayed. The increase in size by spraying any variety of apple with a fungicide will depend upon variable conditions, such as locality and season, but some increase may be expected upon most varieties in nearly all cases. Increase in size of the apples is a comparatively unimportant consideration in spraying, yet this alone would pay upon many varieties.

RATIO OF MARKETABLE APPLES AS AFFECTED BY SPRAYING WITH FUNGICIDES.

"In assorting into different grades, all that were marketable were put into the first and second classes, while those of the third class were fit only for cider or to feed stock and were classed as unmarketable.

TABLE IV. RATIO OF MARKETABLE APPLES AS AFFECTED BY SPRAYING.

Variety	Per cent. marketable	Per cent. unmarketable
Benoni, sprayed	93	7
Benoni, not sprayed	62	38
Northern Spy, sprayed	99	1
Northern Spy, not sprayed	87	13
Newtown Pippin, sprayed	89	11
Newtown Pippin, not sprayed	40	60
Rome Beauty, sprayed	100	00
Rome Beauty, not sprayed	81	19

"This makes a very decided showing in favor of the sprayed apples. There was a gain of 31 percent with the Benoni; 12 with Northern Spy; 49 with the Newtown Pippin and 19 with the Rome Beauty. With some varieties the difference caused by spraying would be much less, in fact cases might occur where there would be no appreciable increase of marketable product of sprayed over unsprayed, but with most varieties spraying with fungicides would increase the number in the first class. It would also prevent the unsightly blackened and sooty appearance often seen upon varieties that are not otherwise affected, and it also has a tendency to heighten the color of red apples and to give a blush to the light skinned sorts. This may be due largely to the effect upon the foliage, but it was quite marked in some cases. Baldwins and Greenings that were operated upon in Ottawa county, where the scab was not seriously prevalent, were benefitted more by the fruit hanging on better upon sprayed than upon unsprayed trees, than in any other particular. This increased the marketable product upon sprayed trees, because there were fewer windfalls, but no notes were taken to show the amount of benefit. The same fact was noted in Lawrence county, but at Columbus the apples were picked too early to note the effect. It thus appears that the table does not fully show the gain in marketable product by spraying. The estimates may be considered as conservative for the varieties named.

MARKET VALUE AS AFFECTED BY SPRAYING WITH FUNGICIDES.

"Taking increase in size and increase in marketable product both into account, it is easy to see that the market value of sprayed apples would considerably exceed the market value of unsprayed. Improved appearance also is a factor that is not to be overlooked.

"In order to put the market value of sprayed and unsprayed apples to the test, equal quantities of each were put upon the market and sold for what they would bring. A sufficient quantity was taken in each case to make the test conclusive. The calculation is made on one hundred bushels, for convenience in illustration."

TABLE V. MARKET VALUE AS AFFECTED BY SPRAYING.

Variety	Value of 100 bushels in market	Increase in value of sprayed over unsprayed
Benoni, sprayed	$56.70	
Benoni, not sprayed	28.60	$28.10
Northern Spy, sprayed	$65.95	
Northern Spy, not sprayed	41.90	24.05
Newtown Pippin, sprayed	$48.91	
Newtown Pippin, not sprayed	22.80	26.11
Rome Beauty, sprayed	$73.44	
Rome Beauty, not sprayed	39.70	33.74

"It appears from the above exhibit that spraying greatly increased the market value of all the varieties named, and in the case of Newtown Pippin the value was more than doubled. The difference was also quite marked with Bellflower and Smith's Cider, but less so with Baldwin and Greening. Complete notes were not taken on these, hence they are not included in the table. Since the cost of spraying did not exceed two cents per bushel, and the average increase in value was twenty-eight cents, it will be seen that the operation was profitable. The sprayed apples sold at a higher price than the unsprayed, and yet went off more readily and quickly. This difference alone would, in some cases, pay for the spraying, in time saved in marketing. Not only does spraying save time in marketing, but as has been shown in previous pages, it makes marketable that which could not be sold otherwise. Had the varieties named been stored, and not put upon the market until late winter or spring, the difference in value of 100 bushels, sprayed and unsprayed, would have been still greater. An experiment to test the keeping qualities of sprayed and unsprayed, not yet completed, shows that the sprayed are keeping much the better. This item would have a decided effect on the balance in many cases. On the whole, the result as it stands is satisfactory. The work was undertaken and carried out on a commercial scale in order to determine what profit there is in spraying. Table V gives a very clear and forcible answer for the varieties named and for one season. More or less variation may be expected for other varieties in different localities, but those who are in the best position to know feel sure that spraying with insecticides and fungicides is a necessity in successful orcharding.

COST OF SPRAYING.

"The cost of spraying will, of course, vary with the facilities for work and with the skill of the operators. Copper sulfate can be had for

about six cents per pound by the barrel, but the price is somewhat higher in smaller quantities. To spray large trees thoroughly nearly one pound per tree is required for four sprayings, or for the season. For trees fifteen to twenty feet in height it is safe to estimate three-fourths of a pound per tree. Three men can spray 200 to 300 such trees in one day. This brings the total cost, including two applications of Paris green, below fifteen cents per tree for large trees, during the season, and less for smaller trees according to size. This estimate is for dilute Bordeaux mixture and Paris green."

WHEN TO SPRAY.

"It should be borne in mind that spraying with fungicides is preventive rather than remedial, hence the first application should be made early in the season. Some results obtained the past season indicate that early spraying is the key to success, and experimenters generally have urged this point. The first application should be made before, or about the time that the leaves open. The Bordeaux mixture alone may be used at this time, particularly if the work is done before the leaves open, but if delayed until a few days after the buds start, and canker worms are known to be present, it is well to add Paris green or London purple."

"The second spraying should be made immediately after the blossoms fall. This application should not be delayed several days, and it is well to commence as soon as the greater share of the blossoms have fallen. There is no necessity of commencing before this time, nor is it advisable. For this application the combination of fungicide and insecticide should be used, i. e. dilute Bordeaux mixture and Paris green or London purple, the insecticide being to destroy the apple worm.

"The third application may be made a week or ten days from the time of the second, and with the same materials. If either ammoniacal copper-carbonate or modified eau celeste is used the Paris green or London purple must be applied alone, since the ammonia present in these solutions renders the arsenites soluble, which endangers the foliage.

"The fourth and last application for the season should be made in about two weeks from the time of the third, and dilute Bordeaux mixture alone used. For early ripening varieties the fourth application may be omitted, or the time between applications lessened. This is to avoid leaving a coating of the mixture on the fruit when ripe.

"In some of our work the past season seven applications were made, but in a part only four were given. The success with the latter number was so good that it seems safe to advise that number of sprayings. It is important, however, to observe closely the time advised for the first and second applications, since success depends more upon these than the subsequent ones. If the weather is rainy during the spraying season it is better to keep the work going than to wait for dry weather. Of course it would be impracticable to spray during a rain-storm, nor would it be best to spray immediately before, but if the mixture has two or three hours

in which to dry before a rain it will adhere so closely that but little of it will be washed off. Much of it will remain for weeks even during very rainy weather. One application made before a storm was repeated the past season immediately after a heavy rain, but with the mixture advised this is hardly necessary, except for a few trees that were sprayed just before the rain came. It is better to spray at the proper time than to wait for dry weather."

CO-OPERATIVE EXPERIMENTS

"Following is the report of an experiment in spraying for apple scab made in coöperation with the Station in Lawrence county, Ohio:

SIR:—I have the honor to submit herewith my report of experiments for the prevention of apple scab, made in Nelson Cox's orchard located five miles from the Ohio river, north of Huntington, W. Va., in Lawrence county, Ohio.

U. T. COX, *Ensee, Ohio*.

W. J. GREEN, *Horticulturist, Ohio Experiment Station.*

The variety of apples experimented on was the Rome Beauty. They were sprayed the first time just after the bloom fell. I sprayed the first two times with the dilute Bordeaux mixture, adding London purple as an insecticide. The last two sprayings were done with modified eau celeste. The Bordeaux mixture is preferable for all four sprayings. The Vermorel nozzle was used.

I sprayed about 175 trees, small size, in one orchard, eastern slope, altitude about 800 feet above sea-level. I selected two trees of the same size as near as I could judge, in the same row and thirty feet apart. Sprayed May 5, 15, June 3 and 23, with frequent rains from June 10 to 22. Picked October 28, 1891. The results are tabulated below:

Treatment	Total yield in barrels	No. first class, free from scab spots	No. second class; slightly scabby	No. third class, very scabby
Unsprayed tree	Nearly 1	None	188	540
Sprayed tree	2	540	268	40

The leaves fell prematurely from the unsprayed tree, and the apples ceased to grow, so they were small and dark-colored, while the ones on the sprayed tree grew to good size and had a very bright red color.

I sprayed May 4, 14, 26, June 23, about 300 trees in another orchard. The two I selected stood on the north side of a hill on comparatively low ground, altitude about 750 feet above sea-level. The leaves fell prematurely from the unsprayed tree here also. Picked October 14. The unsprayed tree had just one barrel, the sprayed tree two and two-thirds barrels. I sent one barrel of each to the Station, so I had none of the unsprayed to compare with the remainder of the sprayed. There was just one peck of culls in the remaining one and two-thirds barrels, the others being first-class and nearly all free from scab spots. You know the result of the two barrels sent you. (See Table III.) There were 800 apples in the barrel of unsprayed and 590 of sprayed.

I sprayed one row May 5, 15, June 3, 24, on very high ground, nearly 1,000 feet above sea-level. The trees were old; the two selected stood in adjoining rows.

Leaves had not fallen from the unsprayed trees here. I did not count the apples from these two, I just sorted and barreled them. The result is below:

Treatment	First class	Culls
Unsprayed tree	1¼ barrels	1 barrel and 1½ bushels
Sprayed tree	3¼ barrels	1 bushel

The unsprayed apples were rough to the touch in every case, while those sprayed were very smooth and bright. A person can shut his eyes and tell the difference by feeling. The finest apples were on the lowest limbs where they were sprayed; in the top where unsprayed. On low ground the unsprayed apples were very dark, and would be worth from twenty-five to fifty cents less per barrel than the sprayed; first class apples as to size in both cases. On high ground there would be but about twenty-five cents difference per barrel of the same class.

The cost of spraying young trees that would yield about a barrel each I find to be about six cents per tree for the season. Those that would yield two barrels each, about nine cents, and those that would yield four or five barrels, twelve to fifteen cents for the four sprayings. The cost of pump and fixtures is not included in the above.

The London purple used did not seem to be as effective on the codlin moth as I hoped for, yet I think it did a little good.

SUMMARY.

"1. The apple scab is a parasitic fungus, growing upon leaf and fruit, and flourishing in cool, moist weather.

"2. The effect of the scab is to cause a large proportion of the fruit to drop while quite small; to greatly disfigure and reduce the size and market value of that which matures, and to injure the vitality of the tree by causing a premature falling of the foliage.

"3. The growth of the scab fungus may be checked by spraying the trees at proper times during the spring with several of the copper compounds commonly used as fungicides.

"4. The most satisfactory compound thus far tested, regard being had to cost, convenience and effectiveness, is a dilute "Bordeaux mixture," containing four pounds copper sulfate, four pounds lime and fifty gallons of water.

"5. While it has not been found practicable to completely prevent the growth of scab in a single season, the experiments demonstrate that it is practicable to so reduce the injury from the fungus that the total value of the crop shall be very greatly increased, and that the value of this increase will far more than repay the necessary cost of using the fungicide.

"6. The effect of judicious spraying with fungicides is to check the dropping of immature fruit in the spring; to cause it to grow to larger size and more free from blemishes; to cause it to hang better to the tree while ripening; to cause it to take on higher color in ripening, and to improve its keeping quality. As measured by market value, spraying has added nearly 100 percent to the value of the crop at a cost of less than fifteen cents per tree."

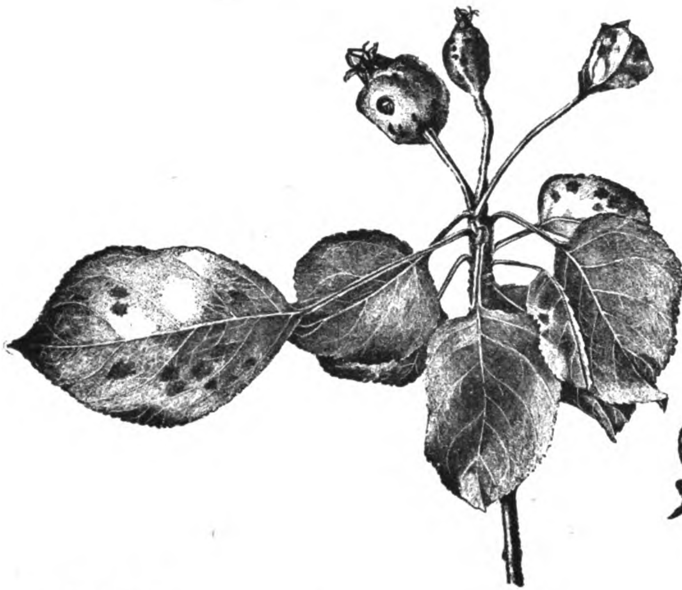


FIGURE 1. The apple scab fungus on young fruit and leaves. This shows the early spring appearance (1891).

FIGURE 2. Apple scab fungus on older leaves (1891). This shows the appearance of scab-infested leaves in the later summer; such are liable to drop early. See page 102.

CORRECTION.

FIGURE 3. Northern Spy, not sprayed; 1st class 7, 2nd class 80, 3rd class 3.
FIGURE 4. Northern Spy, sprayed; 1st class 56, 2nd class 43, 3rd class 1.

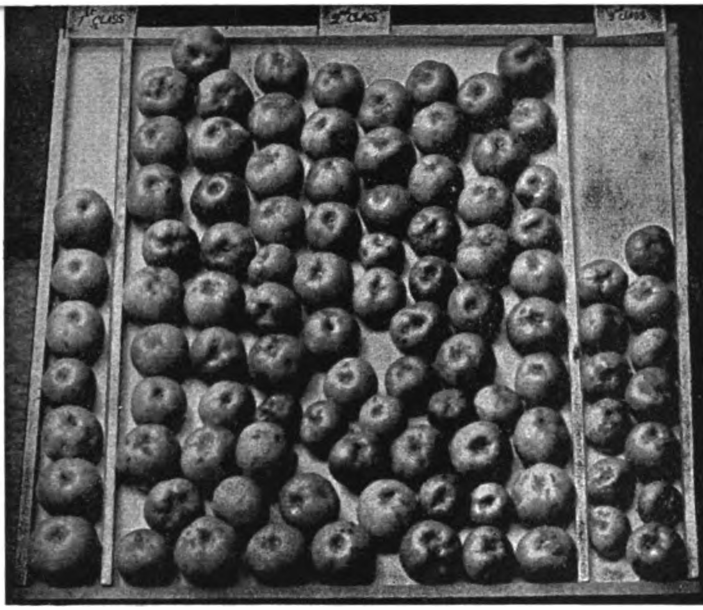


FIGURE 3. Northern Spy, sprayed; 1st class 56, 2nd class 43, 3rd class 1.
(1891.)

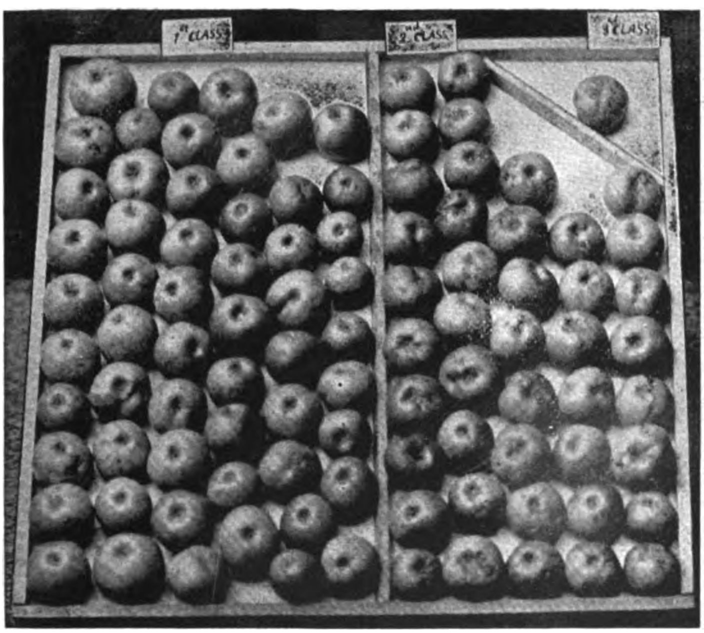


FIGURE 4. Northern Spy, not sprayed; 1st class 7, 2nd class 80, 3rd class 3.
(1891.)

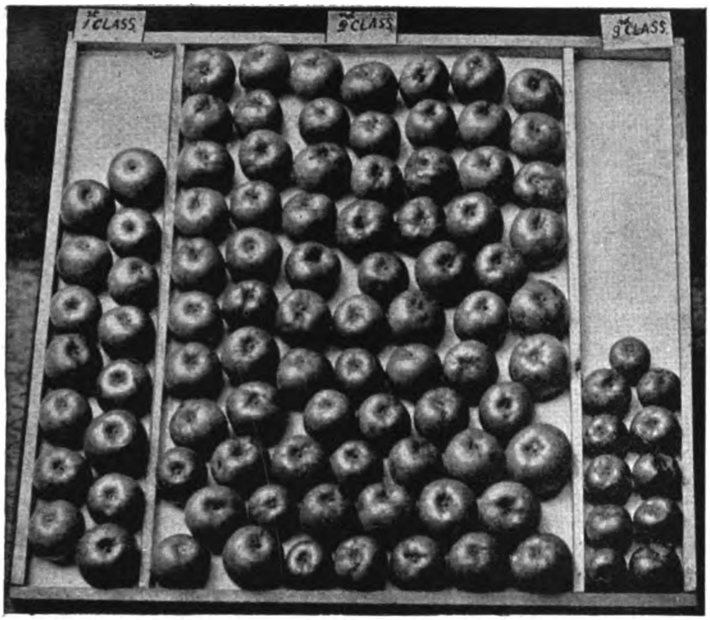


Figure 5. Newtown Pippin, sprayed; 1st class 15, 2nd class 74, 3rd class 11. (1891.)

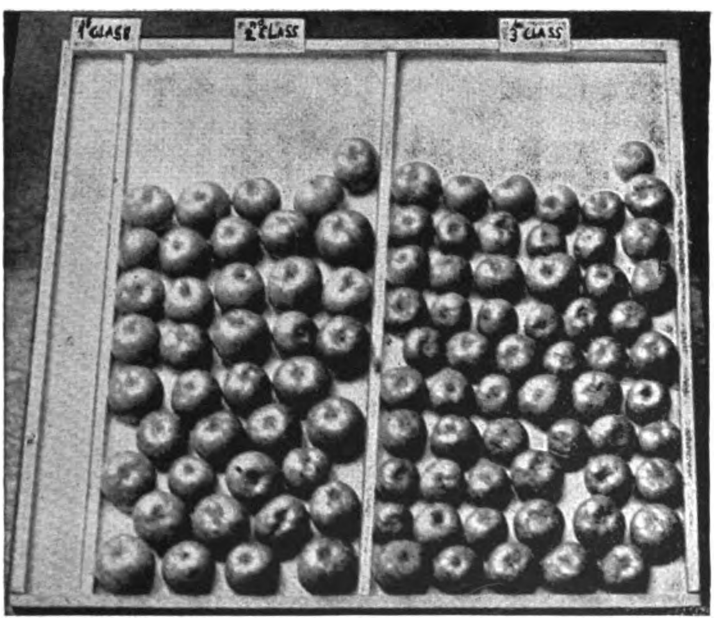


Figure 6. Newtown Pippin, not sprayed; 1st class 0, 2nd class 40, 3rd class 60. (1891.)

PRACTICAL APPLICATION OF APPLE SPRAYING BY GROWERS. (1894).

Upon the publication of the Station's work in 1891, many apple growers proceeded to apply the successful remedy, Bordeaux mixture. Some very striking results obtained by Mr. F. P. Vergon of Delaware, Ohio, in 1894, merit reference here. The lesson of this particular work, as of much other spraying, *is that it saved the crop of fruit.* Four sprayings were made beginning with the opening of the buds and closing with a single application after the dropping of the blossoms. From a number of trees experimented upon, two average ones of the sprayed and unsprayed trees were selected, the fruit from each gathered and piled in adjacent heaps.

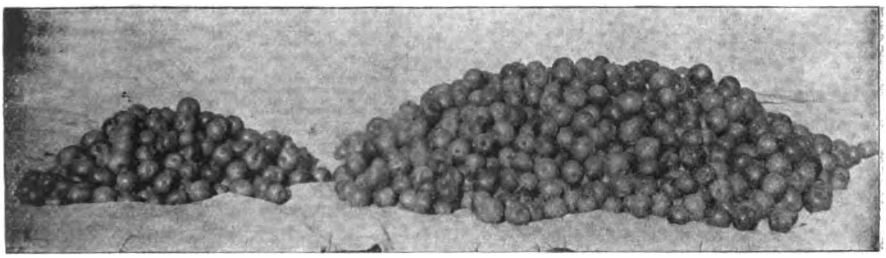


FIGURE 7. Spraying for apple scab in 1894, by Mr. F. P. Vergon, Delaware, Ohio. On the left 1¼ bushels unmarketable apples from one tree not sprayed; on the right 6½ bushels of fine apples, all marketable, from one sprayed tree of same age and variety of fruit.

One and one-fourth bushels of scabby; unmarketable apples were obtained from the average unsprayed tree and six and one-half bushels of fine apples, all merchantable, were obtained from the average sprayed tree. Mr. Vergon practices spraying with Bordeaux mixture and arsenites, each year.

SPRAYING FOR APPLE SCAB IN 1897.

In 1897 Prof. Green again published the results of that season's spraying with Bordeaux mixture for apple scab. The paper was in his "Fruit Notes" for the State Horticultural Society and was printed in the Thirty-First Annual Report Ohio State Horticultural Society, pp. 11, 12. I quote this portion here:

"The efficacy of spraying has often been discussed in these meetings, but I cannot pass the present season's results by without reference in these notes.

"A general crop was not possible, because of the previous season's crop, but a general failure was not necessary.

"The cause of the apple crop failure where the trees bloomed last season must be laid mostly to the apple scab fungus, as it was more than ordinarily severe, and where proper treatment was given more or less of a crop was secured. In all of the Station's experiments no more strik-

ing results have ever been secured than those of last season, where the cost of treatment was repaid more than ten dollars to one.

"The orchard in question has been sprayed five years, except two rows which have never received treatment. Some trees of each variety are in the sprayed portion and some in the unsprayed.

"Taking the average yield, of the sprayed and unsprayed trees separately, we have the following results:

Northern Spy,	sprayed, ave. per tree..10.0 bu.	Unsprayed, ave. per tree.. 6.5 bu.
Baldwin,	" " " " .. 8.5 "	" " " " .. 3.25 "
Pearmain,	" " " " .. 3.6 "	" " " " .. 0.75 "
Baltimore,	" " " " .. 7.0 "	" " " " .. 3.5 "
Ohio Pippin,	" " " " .. 6.6 "	" " " " .. 0.5 "
Wells,	" " " " .. 5.3 "	" " " " .. 1.00 "
Grimes' Golden	" " " " .. 6.25 "	" " " " .. 1.5 "

"The average per sprayed tree was 6.75 bushels, and of the unsprayed, 2.42. Fifty sprayed trees produced 4.33 bushels of apples more per tree than the unsprayed, which was secured at a cost of not more than 20 cents per tree. In the case of the Northern Spy and Baldwin the actual profit derived from the treatment was more than $5.00 per tree.

"By unsprayed trees are meant those on which no Bordeaux mixture was used, but Paris green was applied to them for the apple worm. Some injury was done to the foliage in this manner. These trees suffered not only from the effect of the apple scab fungus but from the added injury of the Paris green. In thinning the fruit when small, in mid-summer, the poorest fruit was taken off. Both these factors make the benefit from the treatment from Bordeaux mixture appear greater than it really is, but there is sufficient evidence to show that the effect of the treatment was highly beneficial. A further factor, on the other side, in favor of the treatment, but which does not show in the above tabular statement, is that of improvement of keeping qualities of sprayed fruit. This is enough to offset the entire cost of treatment, and would make up for the injury done by Paris green.

"It is proper to state the fact that when the foliage of the tree is diseased it is much more susceptible to injury by Paris green or London purple than when healthy."

SPRAYING FOR APPLE SCAB IN 1899.

The results of apple scab treatment in 1899 are equally striking compared with those of previous seasons. The work has been continued at the Station while a number of apple growers give the same testimony as in the past, save that possibly losses from codlin moth have been rather greater than usual.

Mr. Nelson Cox reports by his son C. G. Cox a very fine showing from the use of arsenites and Bordeaux mixture. They estimate their increased product as sold for $1000 more than it would have been worth without spraying, and at an outlay of about $125 to $150.

While there are still problems connected with the parasites of the apple orchard, the demonstration of the commercial value of spraying with Bordeaux mixture and arsenites appears now to be on a basis of general acceptance. In this later Ohio work, as in the earlier, the mixture has been used of the same strength as that given on page 95, namely 4 pounds copper sulfate and 4 pounds of lime to 50 gallons of water.

RASPBERRY ANTHRACNOSE.

In October, 1891, the Station Botanist and Horticulturist published, in Bulletin No. 6, Vol. IV., descriptions and treatment methods for raspberry diseases. In this publication it was shown that as a result of experiments in spraying with the dilute Bordeaux mixture the anthracnose fungus (*Gloeosporium venetum* Speg.) has been held in check. I quote from the bulletin —

"The treatment seems to have been very beneficial, and is referred to here in order that those interested may know what materials to use. The following, which is a dilute Bordeaux mixture, gave the best results:

Copper sulfate, 4 pounds.
Lime, 4 pounds.
Water, 50 gallons.

"To prepare the mixture the copper sulfate should be dissolved in two gallons of hot water, and the lime, which should be quick-lime, should be slaked slowly and water added sufficient to make a thin paste, or milk of lime. The copper sulfate solution is then to be poured into the lime, after which water sufficient to make 50 gallons is added. The quantity of lime recommended is more than is needed, but in practice it is found to be quite difficult to reduce all of it to the required consistency, and more or less remains in the bottom of the vessel in the shape of small lumps, which if left in would clog the nozzle; hence it is necessary to strain the lime paste before using, which occasions some loss, but leaves sufficient for the purpose.

"The first application should be made early in the spring before the leaves open, at which time the spraying should be very thoroughly done. The second application should be made soon after the young canes appear above ground, and the spray directed to them alone. The third application is to be made in about two weeks from the date of the second, taking the same precaution to spray the young canes only. The fourth and last application for the season should be made just previous to the time of blooming in the same manner as advised for the second and third spraygns. Raspberry leaves are very tender, and the mixture injures them slightly, but not enough to preclude its use, especially if some care is taken to keep it off the leaves of the bearing canes. The leaves on the young shoots of the current season's growth are not so easily harmed, hence no pains need be taken to keep it off them.

"Six ounces of carbonate of copper dissolved in three pints of ammonia, to which fifty gallons of water are added, has been used with nearly as good results as the above, and with even less harm to the foliage; but all things considered, the dilute Bordeaux mixture is preferred. The raspberry canes that have been treated with the above compounds are almost entirely free from the disease, and no doubt the crop will be much larger than upon the untreated plants. The prospect is so assuring that fruit

growers are advised to make a trial of the treatment for themselves. It should be remembered that the remedy is preventive, hence the first application is probably the most important of all."

While some others have not obtained equally satisfactory results in the use of Bordeaux mixture the outcome of the above described experiments in the following season was practically as anticipated. Professor Green has since repeated the experiments with like favorable results. The work of the Ohio Experiment Station demonstrates that the raspberry anthracnose is amenable to treatment with Bordeaux mixture when this fungicide is applied as described above.

SHOT-HOLE FUNGUS OF THE PLUM.

In the bulletin containing the results of apple scab prevention in 1891 (Vol. IV, No. 9) reference was made by the Horticulturist to the effects of spraying upon shot-hole fungus of the plum (*Cylindrosporium padi* Karst.) It was noted also that "one application of Bordeaux mixture (dilute) was very beneficial, and no doubt two or three are sufficient." Paris green is also recorded as having aggravated the trouble where applied alone. Other experimenters likewise reported similar effects, but definite recommendations were usually omitted. Fairchild* has recorded the variability of the trouble and its dependence upon weather conditions.

The writer has been afforded an excellent opportunity of pursuing the matter further. In 1896, the month of May was very warm and generally marked by a deficiency in rainfall of 1.5 inches. The succeeding June, on the contrary, was very wet save in a few localities. Although the mean rainfall was scarcely 1 inch above the normal, precipitation occurred on 28 days of the month. July was even wetter than June, rain falling on 23 days of the month, the mean amount reaching 8.11 inches, or more than double the normal for this month. August rains were also slightly in excess. Under these conditions the fungus in question developed to an unusual extent. Nearly all plum orchards that had not been treated with fungicides suffered from the fungus; defoliation of trees was a general complaint. In many instances the loss of old leaves occurred early in August, followed by new leaves and blossoms. After such a record there came a great deal of injury from freezing in winter. The matter was presented before the Ohio State Horticultural Society in December, 1897.†

WINTER INJURY TO PLUM TREES AFTER SHOT-HOLE FUNGUS.

"In his report one year ago the writer pointed out the prevalence of shot-hole fungus and leaf-spot on plums and cherries, but did not anticipate at the time the serious winter consequences that befell the plum trees thus affected. In three and four year old orchards of Ottawa county,

* Bulletin Division of Veg. Path. U. S. Dept. Agric. No. 3, pp. 62 and 63; No. 6, pp. 39 and 40.

† See 31st Annual Report, Ohio State Hort. Soc. pp. 82–84.

fully one-half the trees were killed outright or were so severely frozen back as to be of little value. I have in mind an orchard near Elmore that suffered in this manner, but with unequal effects upon different varieties. In order of worst injury the sorts are: Beauty of Naples, Niagara, Bradshaw, Reine Claude, Geuii, Lombard, Shipper's Pride and Yellow Gage, the latter least injured of any. Nearly 50 per cent of the trees were practically destroyed. This orchard was attacked by the shot-hole fungus in 1896. Another large orchard near La Carne showed some striking results. The trees had been most of them defoliated about the first of August, 1896, and as reported to me, with specimens by the owner, had put forth new leaves and blossomed afterward. The leaves sent for examination were abundantly spotted with shot-hole fungus. The same trouble had been present to a limited extent in 1895. During that season the orchard was in corn and this fact was thought at the time to favor the spread of the shot-hole fungus. The fungus was neglected and greater injury followed.

"There are three portions of the orchard. In one the trees are 6 to 8 years planted, in another 3 years, and in another 1 year only from transplanting. Several of the 8 year old trees were destroyed through freezing of the trunks on south, southwest and east sides, and the separation of the bark. It is not with the variety, Coe's Golden Drop, an unusual injury in winter, but the severity is not common. Out of 10 trees of that sort, 5 or 6 were badly injured and 3 a total loss. There was a good deal of killing back on the large trees of other varieties. This was marked on 6 year Lombard and on other sorts as well. The younger trees suffered still worse. Among the 3 year trees practically all of two varieties, Bradshaw and Imperial Gage, were killed to the snow line. At the time of the severest cold last winter, quite a heavy snow lay upon the ground. The snow generously shielded the bases of the trees but all that part of the tree above it was badly frozen. Even where the trees put out new growth, the interior of the old wood seemed brown and dead. It is scarcely likely that any of the trees of these sorts will survive except by renewal from the base, which is possible with a part only.

"Among the 1 year trees, the Stanton variety was entirely destroyed, the interior of the trunks being brown; Reine Claude and Geuii were damaged. Killing back occurred in all the 3 year old sorts, including Bradshaw, Imperial Gage, Lombard, Niagara, Moore's Arctic, Shipper's Pride, Pond's Seedling, German Prune and Yellow Egg, named in order of injury. Those worst affected are named first. The Japanese sorts were not attacked by shot-hole fungus and were not winter killed.

EXPLANATION OF THE WINTER INJURY.

"The explanation lies in the late soft growth and general immature condition of the wood. As has been stated, the trees put out new foliage after the fungus had destroyed the first crop of leaves. All the growth made after August 1st remained unripened, and since all parts

participated in the growth, all were alike susceptible to freezing. Why the sorts like Coe's Golden Drop, Bradshaw and Imperial Gage should suffer more severely than other varieties, under the same general conditions, remains to be explained. Difference in habit of growth may account for it, or it may be a matter of varietal hardiness which may still be another name for the first suggestion. Throughout northern Ohio this severe injury occurred upon plums that had been defoliated by shot-hole fungus. It appears to be a new phase of the shot-hole fungus question and of such importance as to challenge study. The prevention lies in the avoidance of unripened conditions. This means under these conditions the prevention of the fungus by spraying, which is secured by about three applications as per the spray calendar. An additional spraying may sometimes be required. The spraying brought out, this year, an interesting fact. Older leaves on sprayed trees remained uninjured till the end of the season, while the leaves which were upon growth made after the last spraying (June 16) were taken off by the shot-hole fungus."

The statements made above as to spray treatment required is based upon the experiments of 1897, conducted in the orchard of Mr. J. W. Snider at La Carne, Ohio, the same in which severe injury occurred the previous winter. The orchard was divided for treatment into check lots and those to be treated one, two and three times. Applications of Bordeaux mixture were made on May 11, May 26 and June 16 to the respective portions.

In the summer of 1897, July only gave much rainy weather, so that the amount of injury from the shot-hole fungus was not so marked at any point. There was more of it on the trees receiving only the earlier applications of fungicide; yet, as noted above, the leaves on these late sprayed trees were saved just as far as covered with the fungicide. No more injury probably would have occurred, or but little more, under the conditions of the previous season; under normal conditions no injury at all. It is accordingly clear that effective fungicidal treatment for shot-hole fungus should begin when the leaves are half-grown, or slightly larger, and be continued at intervals of about three weeks — the last spraying may be made as late as the condition of the fruit will admit, yet will serve its purpose any time after June 15, in Ohio. The same fungus is likewise checked upon the cherry, but owing to the tender foliage, the Bordeaux mixture should be reduced to 1:25 strength, or two pounds each of copper sulfate and lime to 50 gallons of water. It is then effective and inflicts no injury to the leaves.

BROWN ROT OF THE PLUM.

The brown rot, (*Monilia fructigena* Pers.), is the most destructive disease of the commercial plum grower in our state and the most difficult to control. This latter character evidently exists because of the direct relation of the weather conditions to the development of the rot fungus. If these conditions be bright and fair, or interspersed by occasional showers and clearing weather to follow, unless temperatures be excessive the losses from rot may yet remain inconsiderable; but should consecutive rainy days and high temperatures prevail together, as is so liable to occur during the plum-ripening period or that immediately preceding, losses from rot are an almost certain result. Experiments, therefore, will yield diverse results under the varying temperature and precipitation. One will be likely to meet quite as many negative as positive results. Such has been the outcome at this Station.

EXPERIMENTS FOR THE CONTROL OF PLUM ROT.

The writer conducted a carefully planned series of experiments in 1897 in combination with Mr. B. H. Elwell, Gypsum, O. The details of the experiment are of little moment since the check, unsprayed trees gave little rotten fruit and no difference between the treated and untreated trees could be discovered. It may be stated that all mummy fruits from the previous year's decay were removed and destroyed in all cases; this is a first requisite for the handling of rot and may be supplemented by the spraying and care for rotted fruits, as is shown by some work by Professor Green at this Station in 1898.*

"If we may judge from the past, plum as well as peach culture must fall into the hands of specialists. Last season's results with the plum rot were discouraging. The wet season favored the disease, but it can hardly be denied that as the number of trees increase, so do their enemies. The plum rot now seems to be the greatest obstacle to plum culture, but the results at the Station last season indicate that it may be held in check in a great measure. Our orchard is not well calculated to give the best results in such experiments, as only two-thirds of the trees are sprayed, leaving one-third to breed disease and contaminate the others. It is our custom to make about four applications of Bordeaux mixture, while one tree [in every group of three] is left unsprayed. All the trees are jarred for curculio. Incidentally it may be said that those trees which were both sprayed and jarred had a heavier crop of plums when our countings were begun. It seems to be easier to control the curculio by spraying and by jarring, both, than by either method alone. When we began picking rotten plums, July 13, many of the unsprayed trees had not enough left to make a good crop, but all of the sprayed trees had to be thinned more or less. The picking and counting of rotten plums

* 32nd An. Report, Ohio State Hort. Society, 1898, p. 28.

was continued at frequent intervals throughout the season. The first picking and counting showed that 36 percent of the unsprayed plums had already rotted, while of the sprayed only four percent were diseased. It was not supposed at first that it would be necessary to begin the removal of rotten plums at so early a date, and the work was not begun as early as advisable, hence the disease had secured such a foothold that it was carried to all the trees in the orchard by the wind. Two additional sprayings were given to some of the trees, and with beneficial results, the only objection to such a course being that the mixture remains on the plums when ripe. Had all the trees been sprayed from the beginning and the rotten plums removed from the date when we commenced, it seems safe to say that four applications of Bordeaux would have been sufficient to insure a crop. We got a fair crop from the sprayed trees, the loss from rot being 33 percent, while the loss on the unsprayed trees was 84 percent. When we consider that the effect was uniformly the same on different varieties these results are encouraging. Spraying for peach rot was successful in about the same degree, and for peach scab also."

DISEASES OF THE PEACH.

With the beginning of the writer's work at the Station in the fall of 1894, plans were laid for an investigation of peach diseases and experiments in spraying peach trees. He had been called in consultation in 1892 upon this matter; in 1893 the Station Horticulturist had begun a comprehensive spraying experiment upon newly set orchards of various kinds of trees at Wooster, and had continued this work in 1894. While at that time the more prominent peach diseases had received more or less study, usually disconnected, only a portion of these troubles had been published upon. Without entering into a chronological statement here, there appeared a promising field for that study, and it was undertaken. Discussions of certain results of these studies were presented before the Ohio State Horticultural Society in 1895 (29th Rept., pp. 74-76 and 80-83) and again in 1896 (30th Rept., pp. 87-90). The earlier papers dealt with the crown gall trouble and with the successful first prevention of brown or pustular spot (*Helminthosporium carpophilum* Lév.)

Publication in collected form was made in March 1898, in Bulletin No. 92, entitled "Preliminary Report upon Diseases of the Peach — Experiments in Spraying Peach Trees." In March 1899 this was supplemented by "Further Studies upon Spraying Peach Trees and upon Diseases of the Peach," in Bulletin No. 104. Both these bulletins are illustrated.

In the Preliminary Report upon Diseases of the Peach, after exhibiting the distribution of peach growing and the occasion for the study, five subdivisions are made of the diseases, namely, —

I. Diseases due to mechanical agencies or unfavorable soil conditions.

II. Injuries due to atmospheric conditions.
III. Diseases referred to unknown or doubtful causes.
IV. Fungous diseases of the peach.
V. Diseases caused by animal organisms other than insects.

Under the first sub-division wounds and undrained soil are treated; under the second freezing, windstorms and hail; under the third (1) Yellows, (2) Rosette, (3) A twig disease or the Gum-flow, (4) Dropsical swellings of branches, (5) Twig spots, (6) Crown gall; under the fourth (1) Rot, (2) Scab, (3) Brown or pustular spot, (4) Anthracnose, (5) Mildew, (6) Leaf curl, (7) Leaf spots, (8) Constriction disease of stem, (9) Twig-blight and Twig-spots, (10) Root-rot; and under V mention is made of injuries caused by nematodes and a reference to the attacks of borers and root lice.

Of these diseases, yellows, crown gall, rot and leaf curl are regarded as the most menacing in somewhat the order named. No addition was made to earlier observations on yellows by Dr. E. F. Smith.* Crown gall has given promise of developing into a very serious disease of the peach, especially for younger trees. It comes as excrescences upon the roots and crown of the tree and occasionally upon the stem at some distance above the earth-line; in the ordinary form it is often conspicuous upon nursery stock. The diseased trees usually die before they attain bearing age and the communicable nature is predicated. Peach trees set in a raspberry plantation affected with crown gall became attacked by the crown gall to the extent of 70.8 percent in two years. (B. 104, p. 211.) Prevention of infection was not secured by treatment with flowers of sulfur in the contact soil. Destruction of affected trees is recommended. The cause of crown gall remains in doubt. The rot, as with plums, which are attacked by the same fungus, has proved at times very destructive. The treatment consists in the destruction of rotted fruits and in the use of fungicides. No experiments have been conducted in this line, at least not carried to completion. Some were planned and the treatment applied but no positive results were secured. Leaf curl, fruit scab of peach and pustular spot were the subject of quite extended experiments to be now described.

EXPERIMENTS IN SPRAYING PEACH TREES.

These experiments were conducted by the Station Botanist in the orchard of Mr. William Miller, Gypsum, Ottawa county, with the owner's coöperation and upon a commercial scale from 1895 to 1897, inclusive. Similar treatment for leaf curl and scab was continued by Mr. Miller in 1898. Several varieties of peach that proved susceptible to the attacks of the leaf-curl fungus (*Exoascus deformans* B.), had been extensively planted in this portion of Ottawa county, where peaches are very largely grown. Among these varieties was the Elberta, which had been largely

* Bulletins No. 9, Div. Botany; No. 1, Div. Veg. Path.; No. 17, Farmers' Bulletin U. S. Dept. of Agric.

planted in the newer orchards, but the attacks of the leaf-curl caused marked solicitude particularly in 1893, and to a less extent in 1894. This and other relatively susceptible varieties had suffered very severely. Mr. Miller estimated his loss on the Elberta variety in 1893 at 40 percent of the crop, while in 1894 his estimate was a loss of 5 percent. The writer's attention was called to this serious condition and it was suggested as a subject of importance to the peach grower. Some rather obscure troubles were likewise under investigation in the fall of 1894 when the writer assumed his duties at the Experiment Station. The Station Horticulturist had inaugurated an extended spraying experiment upon the newly planted orchards at Wooster. During the seasons of '93-94, although these trees were young, some decided indications were obtained from the application of the dilute Bordeaux mixture, which was applied just before the opening of the blossoms and again just after these had dropped. Accordingly the chief reliance was placed upon Bordeaux mixture with alternative test of copper sulfate solution for the first application. In all cases the Bordeaux mixture was prepared by using equal weights of copper sulfate and unslaked lime; that is, an excess of lime was uniformly added. Since it was first necessary to determine the effect of the standard fungicide the original plan was followed through three years, except that the copper sulfate solution was not used in 1897. For the applications made after the blossoms had fallen, in all cases, a reduced strength of Bordeaux mixture, 2 pounds each of copper sulfate and unslaked lime and 50 gallons of water, or a 150 gallon formula was employed. Two orchards were under experimentation, known respectively as the South Orchard and North Orchard. The South Orchard occupies about 18 acres; while the North Orchard is almost as large though less of it was under experimentation. The orchard diagrams will be found in Bulletin 92. The following are the spraying schemes for these orchards, '95 to '97 inclusive:—

SOUTH ORCHARD SPRAYING SCHEME

Variety	No. of row	Treatment In 1895	Treatment In 1896	Treatment In 1897
Elberta	1	1″ lye solution	3″ and 4″ Bord. II.	Unsprayed.
"	2	"	"	"
"	3	"	"	"
"	4	"	"	3″ & 4″ Bord. II.
"	5	"	Unsprayed	2″ & 4″ Bord. II.
"	6	"	2″ Bord. II.	2″ Bord. II.
"	7	"	2″, 3″ and 4″ Bord. II	Unsprayed.
"	8	2″ & 3″ Bord. II	" "	1″ & 2″ Bord. I, [& II
"	9	Unsprayed	Unsprayed	"
"	10	1″, 2″ & 3″ Bord. I, & II	1″, 2″, 3″ & 4″ Bord. I, & II	Unsprayed.
"	11	1″, 2″ & 3″ Bord. I, & II	" "	1″ Bord. I.
"	12	1″, 2″ & 3″ Bord. I, & II	1″, 2″, 3″ & 4″ Cop. Sul. & Bord. II	1″ and 2″ Bord. I [& II.
"	13	1″, 2″ & 3″ Cop. Sul. and Bord. I & II	1″, 2″, 3″ and 4″ C. Sul. and Bord. II	1″, 2″, 3″ & 4″ Bord. [I, & II.
"	14	1″, 2″ & 3″ Bord. I, & II	1″, 2″, 3″ & 4″ Bord. I, & II	1″, 3″ & 4″ Bord. [I, & II
"	15	1″, 2″ & 3″ C. Sul. & Bord. I & II	"	Unsprayed.
"	16	Unsprayed	Unsprayed	"
Crawford	17	1″ only, Bord. I	"	"
"	18	1″ & 2″ Bord. I	"	"
Salway	33	....	"	"
"	34	....	2″, 3″ and 4″ Bord. II	"
"	35	....	" "	2″ and 4″ Bord. II
"	36	....	Unsprayed	"
"	37	....	"	Unsprayed.
		Dates	Dates	Dates
		1″, April 25–26	1″, April 18–20	1″, April 23.
		2″, May 10	2″, May 7	2″, May 5–6.
		3″, May 21–22	3″, May 22–23	3″, May 11.
		....	4″, June 3–5	4″, May 28.

NOTE. Bordeaux I refers to the standard strength of 4 pounds copper sulfate and 4 pounds lime to 50 gallons of water, or the 75-gallon formula — Bordeaux II, to half that strength, or the 150-gallon formula. 1″, 2″, 3″, 4″ are equivalent to 1st, 2nd, 3rd, 4th.

NORTH ORCHARD SPRAYING SCHEME

Variety	No. of row	Treatment In 1895	Treatment In 1896	Treatment In 1897
Elberts, S. of Ditch	1	None	None	Unsprayed.
" ...	2	"	"	1", Bord. I. [I& II.
" ...	3	"	"	1",2",3",4", Bord.
" ...	4	"	"	2",3",4", Bord. II.
" ...	5	"	"	Unsprayed.
" ...	6	"	"	"
N. of Ditch.	1	1", Cop. Sul. Sol....	Unsprayed	"
"	2	"	"	"
"	3	"	"	"
"	4	"	3" and 4", Bord. II..	"
"	5	"	3" and 4", Bord. II..	"
"	6	"	Unsprayed	2" & 4", Bord. II.
"	7	"	2", 3" & 4", Bord. II	2" & 4", Bord, II.
"	8	1," 2", and 3", Cop. Sul. and Bord. II..	2", 3" & 4", Bord. II	Unsprayed.
"	9	1", 2", and 3", Cop. Sul. and Bord. II..	2", 3" & 4", Bord. II	1", Bord. I.
"	10	Unsprayed	Unsprayed	1'-&2",Bord.I& II.
"	11	1",2"&3", Bord. I & II	....	....
"	12	2" and 3", Bord II...	....	....
"	13	2", Bord. II.........	....	....
	14	Unsprayed	1" and 2",Bord I & II	Unsprayed.
	15	"	Unsprayed	"
Salway.....	1	"	"	"
"	2	"	"	" [& II.
"	3	"	"	1", 2", 4", Bord. 1
"	4	1", 2", 3", 4", Bord. I, & II..	1", 2", 3", 4", Bord. I, & II	1", 2", 4", Bord. I [& II.
"	5	1", 8" and 4", Bord. I, & II..........	1", 2", 3", 4", Bord. I, & II	Unsprayed.
"	6	Unsprayed	2",3", & 4", Bord. II	"
"	7	"	2", 3", & 4", Bord. II	"
"	8	"	Unsprayed	"
"	9	"	2", 3" & 4", Bord. II	"
"	10	"	2", 3" & 4", Bord. II	"
"	11	"	....	....
		Dates	Dates	Dates
		1", April 25–26	1", April 18–20......	1", April 23.
		2", May 10.........	2", May 7.......	2", May 5–6.
		3", May 21–22.......	3", May 22–23.......	3", May 11.
		4",.................	4", June 3–5	4", May 28.

From the diagrams just given it will be seen that certain rows received continuous treatment, while others were not thus sprayed. Continuous spraying had been begün on the young orchards at Wooster. The continuous treatment in these orchards was in the same line. It was hoped to discover the superiority, if any, of spraying year after year as against occasional or intermittent treatment. The results fully justify provision for such continuance of this spraying. Upon theoretical grounds it would appear possible to eliminate for a time certain parasitic fungi by the continuous use of fungicides. Moreover, from a practical point

of view it would be more economical to treat thoroughly year after year during the seasons of favorable weather conditions, and to attain the more favorable results, than to pursue less regular methods.

As before stated the rows in the South Orchard extend from north to south; accordingly rows at right angles to these were chosen for check purposes in Mr. Miller's spraying of that orchard in 1898. In the North Orchard the test for 1898 was made upon a section of the orchard left untreated in 1897. (Bulletin 104.)

EFFECTIVENESS OF THE SPRAYING FOR LEAF-CURL, (*Exoascus deformans* B.)

One chief object of the spray experiments was to check this fungus of the leaf curl. Attention is therefore directed to the results in this line.

In 1895 weather conditions were such as to develop a very slight amount of leaf curl. There was no observed difference between the sprayed and unsprayed trees in that year.

In 1896 there was a moderate development of leaf curl and the results of the spraying were quite evident. By careful estimates based upon laborious counts it was found that about 2.2 percent of the leaves on unsprayed trees of the Elberta variety in the North Orchard were attacked by the *Exoascus*. In the South Orchard the total amount was a little less on this variety. It was found that four sprayings reduced this amount of leaf curl to .2 percent of curled leaves (less in South Orchard); that is, the prevention of about 90 to 94 percent was attained in this way. (Bulletin 92, page 246.)

In 1897 conditions were favorable for the development of the leaf curl fungus. In this year's treatment certain rows in the orchard which had been sprayed two years were left unsprayed, while certain other rows that had been before unsprayed were this year treated with Bordeaux mixture. Careful counts were made in the orchards from June 12 to June 21, 1897. In Row 16 of the South Orchard, unsprayed in all years, there was about 88 percent of leaves affected with curl June 12 and about 50 percent had fallen June 18; while upon the adjacent Row 15, sprayed in previous years and unsprayed in 1897, there was 14.2 percent of curl affected leaves June 14, and about 8 percent of the leaves had fallen June 21. Upon Rows 13 and 14, sprayed throughout, there was but 7 to 8 percent of leaf curl with a loss of 15 to 20 percent of the leaves on June 21. Here the leaf fall was due to late spraying. On Row 9 of the same orchard, which had been untreated in previous years, the first and second sprayings in 1897 reduced the amount of curl from the 88 percent found upon Row 16 to 41 percent at about the same date of counting. In the North Orchard the results were very similar — in other words, *the spraying saved a good supply of foliage leaves for the peach trees.* There was no fruit in that year. There was conspicuous cumulative effect, as will be seen by comparing the full table in Bulletin 92, page 254. We may note here that Rows 8 and 9 are comparable, Row 8 being treated

in '96 while Row 9 was untreated. With the same treatment in 1897 the amount of curled leaves on Row 8 was 5.6 percent June 14, while on Row 9 it was 41 percent June 15. It does not appear from the next year's work that this cumulative effect upon leaf curl by continuous spraying may be expected under all circumstances. In 1898 in Mr. Miller's continuation of the spraying for leaf curl there was no apparent difference between the results upon the trees unsprayed in previous years and those which had been sprayed throughout. There was apparently a greater number of blossoms in both orchards upon the sprayed trees than upon the unsprayed trees. This season, '98, was one extremely favorable to the development of the leaf curl fungus, which may account for the nearly equal injury upon all of the trees not treated during the season. The illustrations, from photographs by the writer, will show the great difference in the trees which had been sprayed and those receiving no treatment, as exhibited June 11, 1898. Furthermore, the difference in the yield of fruit was very marked. The unsprayed trees yielded only an occasional peach while the sprayed trees yielded about 1.2 bushels per tree. The following statement is furnished by Mr. Miller and reprinted here from Bulletin 104.

SOME RESULTS OF SPRAYING IN THE NORTH ELBERTA ORCHARD OF WM. MILLER.

[GYPSUM, O.]

Number of trees unsprayed	165.
Number of trees sprayed (yield counted)	119.
Number of bushels on unsprayed trees	11.
Number of bushels on sprayed trees	143.
Number of bushels per tree on unsprayed trees	0.066
Number of bushels per tree on sprayed trees	1.21
Number of bushels per tree gained by spraying	1.144
Total bushels lost by not spraying	186.45
Average price per bushel	$1.50
Dollars, gross, lost by not spraying (165 trees)	$279.67

(See also Thirty-second Report, 1898, Ohio State Horticultural Society, page 13. The sprayed and unsprayed trees are adjacent.)

There was a difference in 1898 in the time of spraying; most of the sprayed trees were treated twice before blooming; namely, April 12 and April 30, and again after blossoming on May 17. These experiments covering four years show conclusively the value of Bordeaux mixture as a fungicide against *Exoascus deformans* on the peach. While for most of the work the earliest application was made just before the opening of the blossoms, or at a corresponding time, when the blossoms were killed by winter, the spraying of 1898 by Mr. Miller would suggest the equal efficiency of somewhat earlier treatment. From the series of experiments it does not seem wise to omit the spraying usually made just before the blossoms open. As compared with subsequent ones this is more than doubly effective.

PREVENTION OF PUSTULAR SPOT OF PEACH.

(Helminthosporium carpophilum Lév.)

The fruit in the orchards in which the experiments were made was attacked by this fungus *(Helminthosporium carpophilum)*. It was found in 1895 that the later sprayings (particularly the third and fourth) had prevented the injury from this fungus to a very great extent. The same results were again obtained in 1896. The accompanying summary table will give a clear idea of the effectiveness of treatment given at different times (Bulletin 92, p. 249): —

TABLE SHOWING SUMMARY OF SPRAYING RESULTS ON PUSTULAR SPOT OF PEACH FRUIT IN 1896 — SOUTH ORCHARD.

No. row.	No. trees.	Treatments received	No. peaches	No. per tree	Yield bush.	No. spott'd peach's total	No. badly spotted	Per cent spotted	Per cent badly spotted	Age of trees.
2	37	3 and 4..	6,525	179	43.33	271	11	4.15	.17	7 and 8 yrs.
8	35	2, 3 & 4.	6,057	170	37.25	62	1	1.02	......	"
6	35	2	4,574	131	27.25	300	47	6.58	1.03	"
10	12	2 and 4..	1,427	119	9.	36	3	2.52	.02	"
5	38	Untreat.	6,938	182	43.75	1,130	212	16.28	3.05	"
9	33	"	7,539	228	47.25	1,186	223	15.73	2.96	"
16	33	"	5,609	167	34.	950	161	16.93	2.87	"
11	33	1, 2, 3, 4	5,528	167	32.25	61	.....	1.10	......	"
14	31	1, 2, 3, 4	11,106	273	62.	92	2	.84	......	"
12	26	1, 2, 3, 4	3,008	116	18.50	25	2	.83	......	"

It will be observed that thorough treatment reduced the amount of spotted peaches to less than one percent, while on the average of the unsprayed trees the amount was above 16 percent. In comparison with the prevention of leaf curl, here it is later sprayings, rather than earlier, which are the more effective.

PREVENTION OF SCAB OR SPOT OF THE PEACH.

(Cladosporium carpophilum Thüm.)

These experiments were in particular designed to test the effectiveness of Bordeaux mixture in preventing the scab by continuous treatment. By two years' successive treatment of a susceptible variety, the Salway, in Mr. Miller's North Orchard, the percent of scabby peaches was reduced from about 70 percent to 39.27, and the proportion of those badly affected, which usually means those cracked open and consequently worthless, was

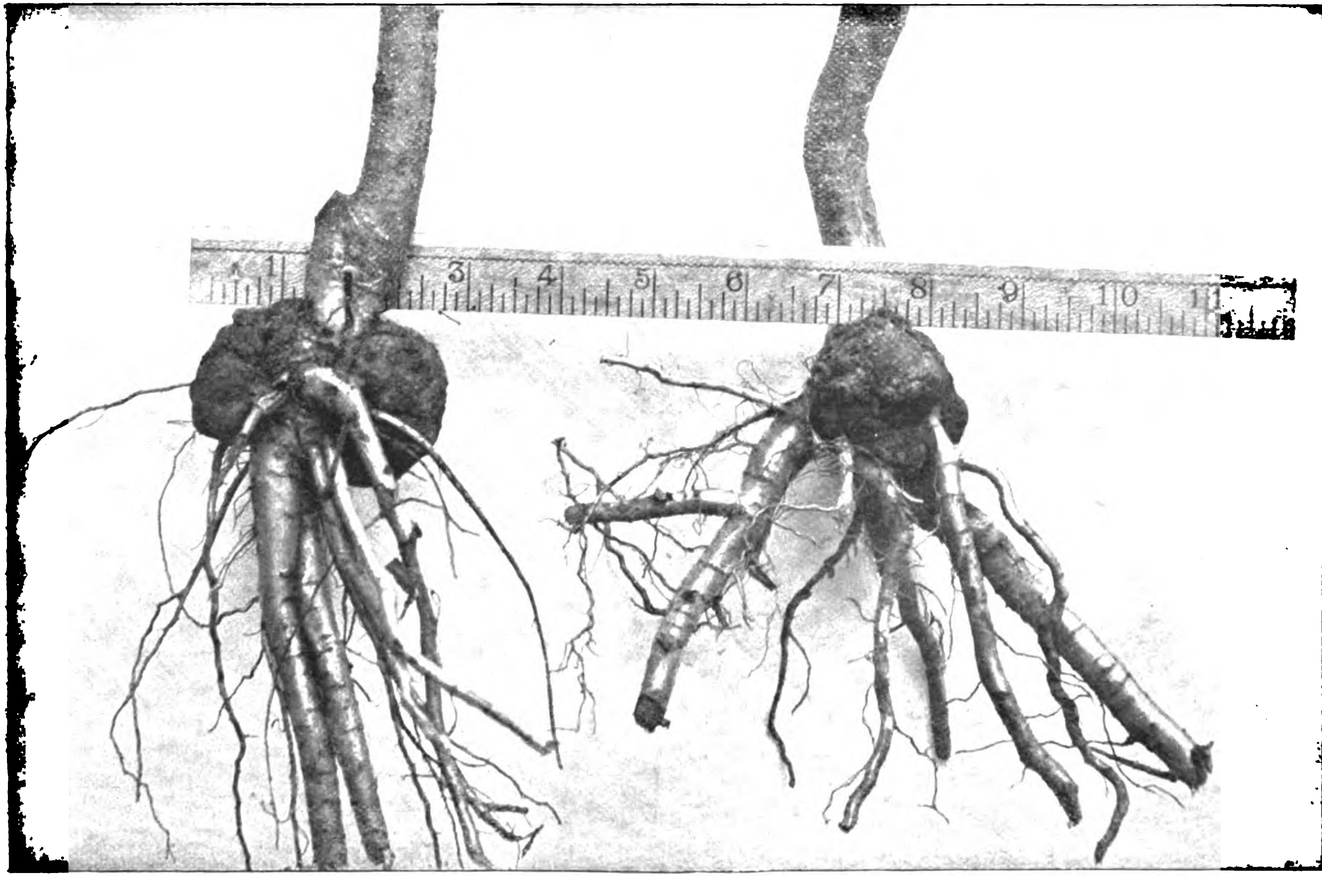


FIGURE 8. Crown gall of the peach. Showing cases of two nursery trees affected by the disease. They show the crown development of the galls. (From a photograph 1897.)

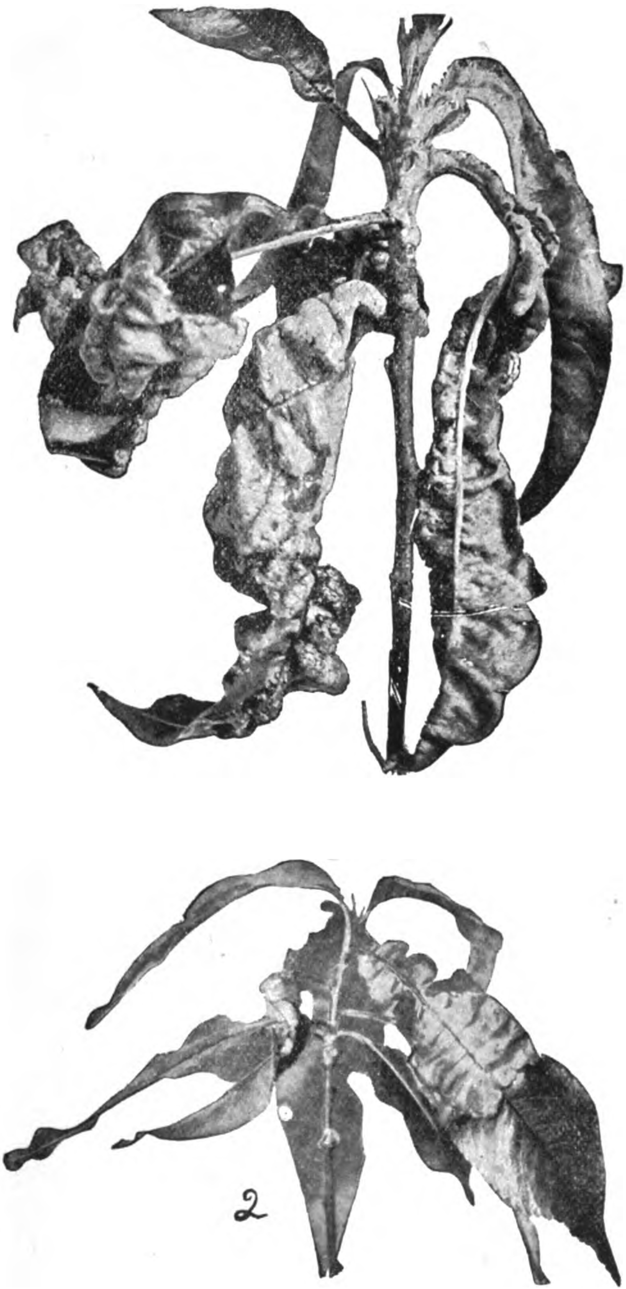


FIGURE 9. Leaf curl of peach caused by *Exoascus deformans* (B): 1 from Ithaca, N. Y., with leaves, petioles and a portion of the stem affected; 2 from Auburn, Ala.

(After Atkinson, Bulletin 73, Experiment Station of Cornell University.)

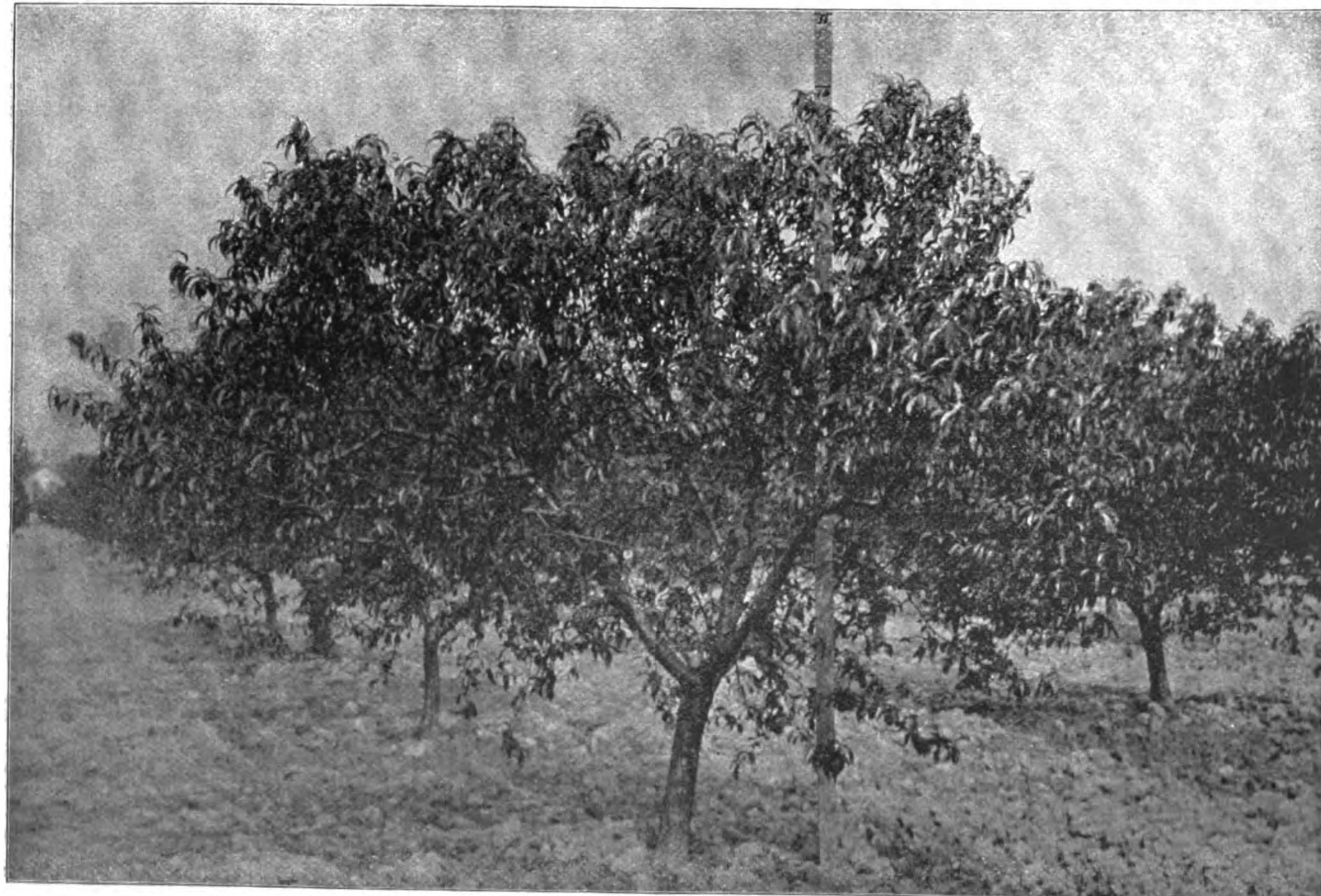


FIGURE 10. Peach tree of Elberta variety 9 years old, sprayed. The tree was sprayed April 12, April 30 and May 17, 1898. (From photograph June 11, 1898.)

FIGURE 11. Peach tree of Elberta variety, 9 years old, not sprayed. From same orchard and same row as Fig. 10.

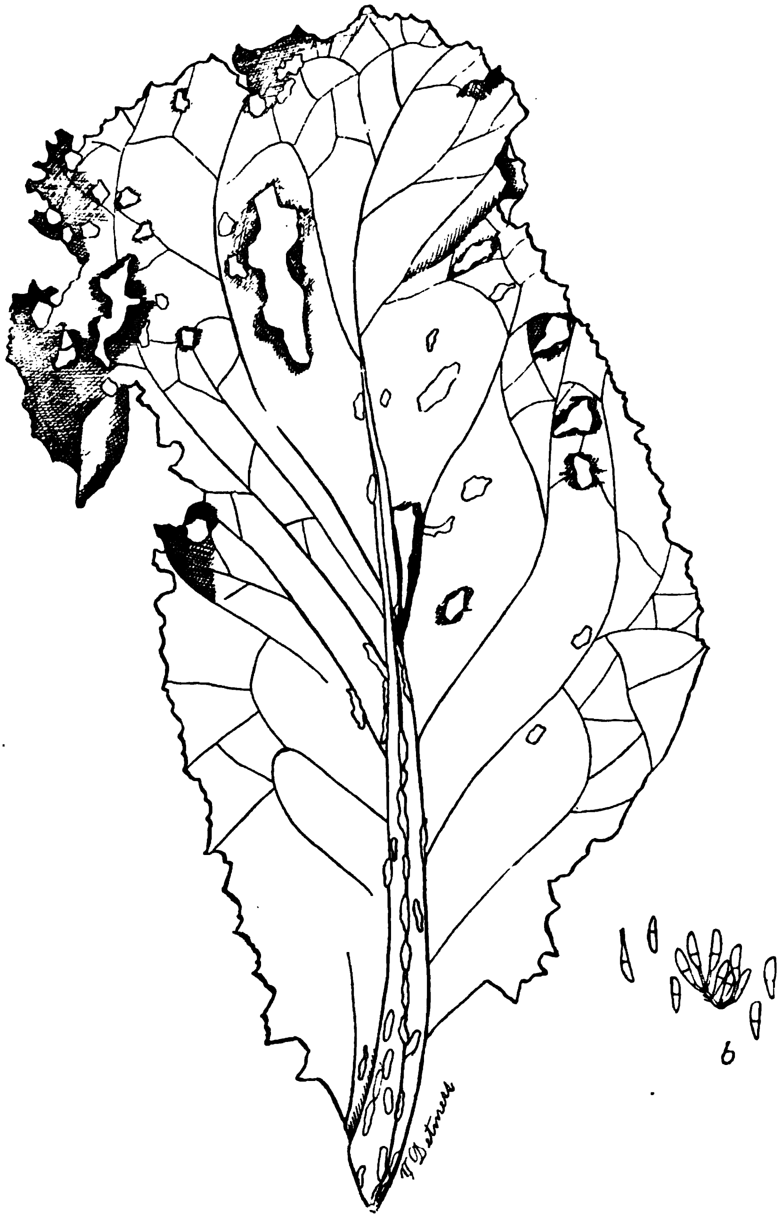


FIGURE 12. A Lettuce leaf attacked by anthracnose or leaf perforation disease. At *b* are shown the spores and spore-bearing parts of this new fungus, *Marsonia perforans* E & E, highly magnified. (1896.)

reduced from about 30 percent to 3 percent. The results indicate very little benefit during the first year's spraying for this fungus. It is the continuous, in this instance the second year's, treatment which is effective.

DISEASES OF PLANTS IN THE FORCING HOUSE.

This Station, and I might add this Department of it, conducted investigations at an early date, to determine the prevalent diseases of the forcing house and the best methods for their control. (Bulletin 73, 1896.)

Among other things included in this bulletin are studies of the diseases of lettuce, diseases caused by nematodes, leaf mildews, diseases of cucurbits and tomato diseases. Under the first title the lettuce drop, or rot, referred to *Botrytis vulgaris* Fr., the downy mildew of the lettuce, (*Bremia Lactucae* Regel), the lettuce leaf perforation, or anthracnose (*Marsonia perforans* E. & E..), a new species therein described, are discussed and methods of control are pointed out. The last named trouble contributed by a lettuce grower at Troy, Ohio, was described and illustrated. It has since been discovered at other points in the United States. Perhaps the study of the diseases caused by nematodes, published in the bulletin named, has been productive of as much good as any similar one of like extent published by this Station. It was pointed out that the small excrescences upon the roots of the rose, the tomato, burdock, *Begonia metallica, Begonia rubra,* the cucumber, the violet, *Abutilon,* (cultivated) *Passiflora* (culivated) and the apple, are due to these parasitic, microscopic worms chiefly referred to *Heterodera.* Large excrescences with the eelworms in them were observed upon the stems and large roots of *Begonia rubra* and *Begonia olvia.* The destructive work of these minute worms upon the roots of forced cucumbers was also studied and illustrated. The effect upon roses was likewise carefully noted and experiments made in the treatment of affected rose plants. No successful remedy was discovered for plants once attacked by the *Heterodera,* and it was pointed out that previous preparation of the earth employed in the greenhouse benches must be relied upon for avoidance of these parasites. Winter handling and rehandling, to secure thorough freezing, was found effective in well rotted sod compost.

A successful result secured by Mr. Lodder, of Hamilton county, in steaming the earth used to grow cucumbers, was likewise published. It seems that this work, which Mr. Lodder was encouraged to undertake, was one of the early applications of the process of steaming soil to prevent the injuries from nematodes.

Among the diseases of cucurbits reference was made to the occurrence of *Plasmopara Cubensis* (B. & C.) upon forcing house plants near Cincinnati and in the garden of the writer at Wooster. This disease subsequently proved very destructive in the pickle and melon fields of the state. The cucumber spot, (*Cladosporium cucumerium* Ell. & Arth.) was noted as attacking the cucumber fruit in Mahoning county. What

was called at the time a new leaf blight of muskmelons and referred to *Alternaria* species, was illustrated and its injurious attacks described.

Under tomato diseases, aside from the common tomato leaf mold (*Cladosporium fulvum* Cke.) a new disease of forced tomatoes was described and illustrated. This disease shows similar symptoms to one described under the name of winter blight, by the Experiment Station of Cornell University (Cornell Bulletin No. 43), but is accompanied by other symptoms of the fruit, namely, dark spotting of the skin and occasionally further effects on the interior of the tomato fruit. The point rot of green tomatoes in the forcing house was referred to water conditions of soil. A second new arrival among tomato diseases, the tomato leaf blight (*Septoria Lycopersici* Speg.) attacking the leaves and stems of garden tomatoes, was also illustrated from Ohio material. Its successful prevention was attained by spraying with Bordeaux mixture, in 1897. (Bulletin No. 89.)

STUDIES OF THE DISEASES OF CUCURBITS AND TOMATOES.

Reference has already been made to the published results of work on the diseases of tomatoes. It remains to give some account of the investigations made with relation to the diseases of the cucumber and melon. In 1897 the general injury in the cucumber, pickle and melon fields of Ohio from the downy mildew (*Plasmopara Cubensis*) was very apparent. Pickle yields in this county, Wayne, became reduced to an amount that ceased to be profitable. (Bulletin 89.) The average for that year amounted to 71 bushels per acre in the county. The cucumber anthracnose (*Colletotrichum lagenarium* (Pass.) Hals.) was also noted and its injuries recorded. Extensive experiments were planned and carried out in 1898 to show what may be done by spraying. These coöperative experiments (with Dr. A. C. Knestrick of Creston, Ohio,) for prevention of downy mildew were very satisfactory. The increase in yield of the sprayed over the unsprayed areas amounted to 75 bushels per acre during a season in which the continuous rains made the early yield almost double that of the usual season. The relation of this earliness of the crop to the injury caused by downy mildew will be understood when we state that this fungus has never appeared earlier in the pickle fields of this section than August 10. It was first noted about August 18, 1897, August 13, 1898, September 9, 1899. So if the pickle crop is gathered by the middle of August the spreading of the disease may be expected to exert but little influence upon the total yield. (See Bulletin 105.)

The effectiveness of spraying for anthracnose of the cucumber was also brought out at Creston and in experiments made by Mr. C. P. Dyar, Marietta, Ohio, the latter upon early market cucumbers. The spraying of muskmelons upon a commercial basis for leaf blight (*Alternaria* species), downy mildew (*Plasmopara Cubensis*) and anthracnose (*Colletotrichum*) was also investigated and successful, as well as unsuccess-

ful, experiments were recorded. (Bulletin 105.) With interest may be noted the large number of new hosts upon which *Plasmopara Cubensis* was collected in the pathological garden of the Experiment Station, Wooster, in 1898. (Bulletin 105, pages 219-20. See also Botanical Gazette, Jan. 1899, Vol. 27, page 67.)

THE PREVENTION OF GRAIN SMUTS.

Experiments in the prevention of the smuts of wheat and oats were begun upon oats at Wooster in 1895. (Bulletin 64.) These were continued in 1896, 1897 and 1898 upon oats and wheat. The whole series was conducted in coöperation with the Agriculturist of the Station. The most striking feature of the earlier work was the enormous amount of loose smut in the untreated oat plots amounting in one variety to 58.82 percent, and in several varieties reaching 30 percent and above. The most effective results were obtained by the hot water treatment, namely, that of immersing the seed oats for 15 minutes in water at a temperature of 133 degrees F. In a subsequent experiment it was found that equally good results were obtained by immersing the seed oats in hot water contained in a suitable open vessel, for 10 minutes at 133 degrees F., or 7 minutes at 136 degrees F., or 5 minutes at 140 degrees and 142 degrees F. with subsequent drying upon clean floor. (See Bulletin 97 by J. F. Hickman and A. D. Selby.) In the same bulletin it is shown that the loose smut of wheat (*Ustilago Tritici* Jensen) may be prevented by soaking the seed grain for four hours in cold water, then allowing it to stand four hours more in the wet sacks and afterwards immersing for 5 minutes in water at a temperature of 133 degrees F., as recommended by Swingle. (Year-book U. S. Department of Agriculture 1895, page 417.) By this method it is necessary to use one-half more seed to replace that injured by treatment.

Successful experiments in the treatment of stinking smut of wheat (*Tilletia foetens*) are recorded. About equally good results were obtained by immersing the seed for 10 minutes in hot water at a temperature of 133 degrees F. and by the action of copper sulfate solution, one pound to 5 gallons of water, for 20 minutes, with the subsequent liming and drying of the seed grain. In the same bulletin the Station Botanist has recorded the results of his study of the fungus of wheat scab, a disease more or less virulent in America and Europe, especially during seasons of excessive rainfall. This disease is referred to *Fusarium roseum* Lk. of which the ascigerous stage is identified as *Gibberella Saubinettii* (Mont.) Sacc. The same is illustrated.

CONCLUSION.

The investigations and experiments outlined in the foregoing pages have demonstrated the possibility of the successful and profitable control of the following fungous diseases of fruits:—

Apple scab (*Fusicladium dendriticum* (Wallr.) Fckl.)

Raspberry anthracnose (*Gloeosporium venetum* Speg.)

Shot-hole fungus of the plum (*Cylindrosporium padi* Karst.)

Peach leaf curl (*Exoascus deformans* (B.) Fckl.)

Pustular spot on the peach (*Helminthosporium carpophilum* Lév.)

Peach spot, or scab (*Cladosporium carpophilum* Thüm.)

Downy mildew of cucumber and muskmelon (*Plasmopara Cubensis* (B. & C.) Humph.)

Anthracnose of cucumber (*Colletotrichum lagenarium* (Pass.) Hals.)

Tomato leaf blight (*Septoria Lycopersici* Speg.)

Investigations have been conducted which made known and demonstrated remedies for point rot of green tomatoes, nematode diseases of the forcing house and fungous diseases of the same. A new disease of forcing house lettuce was published. In these demonstrations this Station has been sometimes a leader, sometimes a follower in a work in which many similar institutions were engaged, and while no claim is made to exclusive success and priority in all the lines of research indicated, it is hoped that they have contributed in some degree towards the extension of the boundaries of useful knowledge.

Ohio Agricultural Experiment Station.

BULLETIN 114.

WOOSTER, OHIO, JANUARY, 1900.

HOW INSECTS ARE STUDIED AT THE OHIO AGRICULTURAL EXPERIMENT STATION.

The Bulletins of this Station are sent free to all residents of the State who request them. Persons who desire their address changed should give both old and new address. All correspondence should be addressed to

EXPERIMENT STATION, WOOSTER, OHIO.

COLUMBUS, OHIO
FRED J. HEER, STATE PRINTER
1900

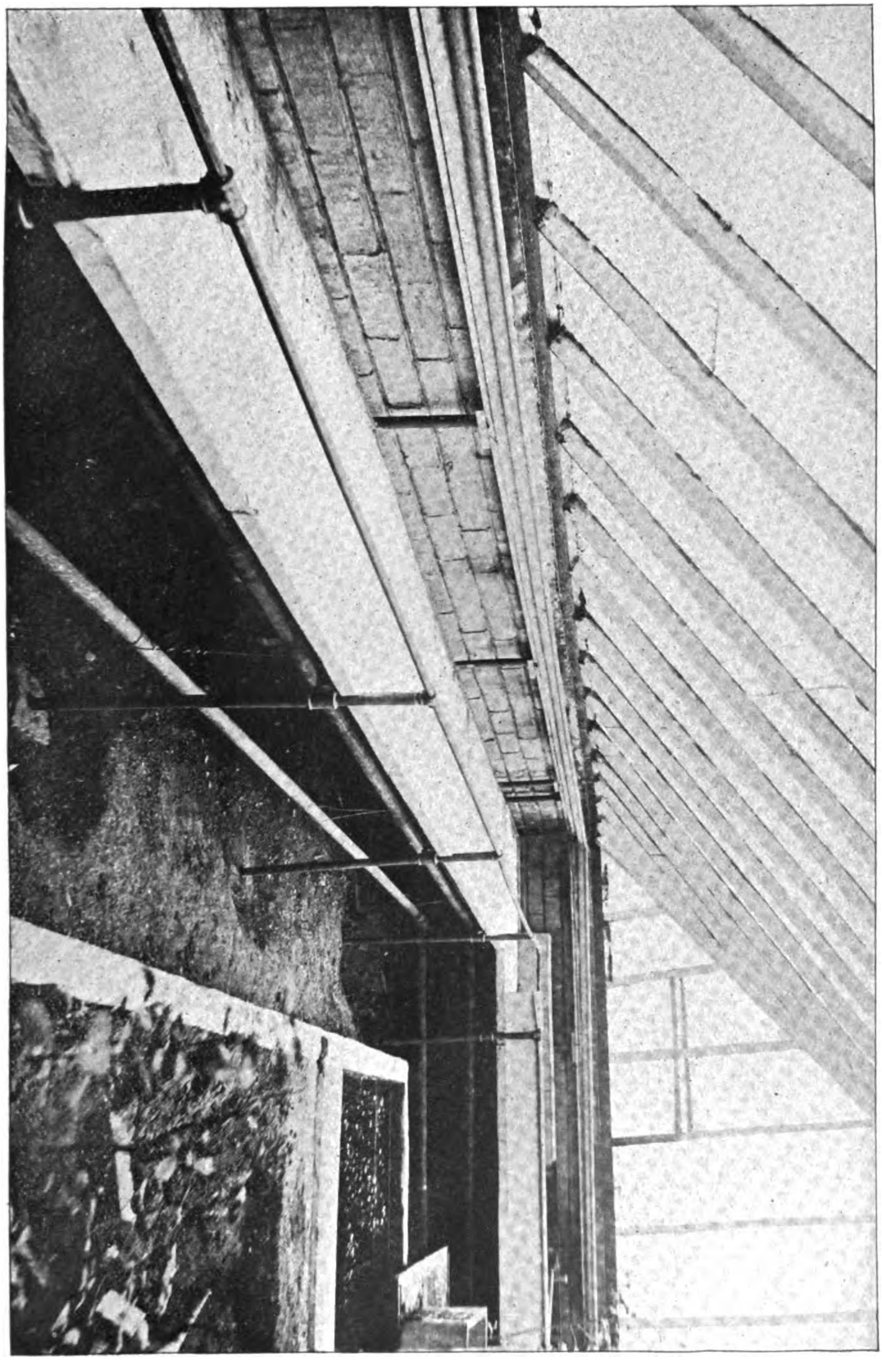
ORGANIZATION OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

BOARD OF CONTROL.

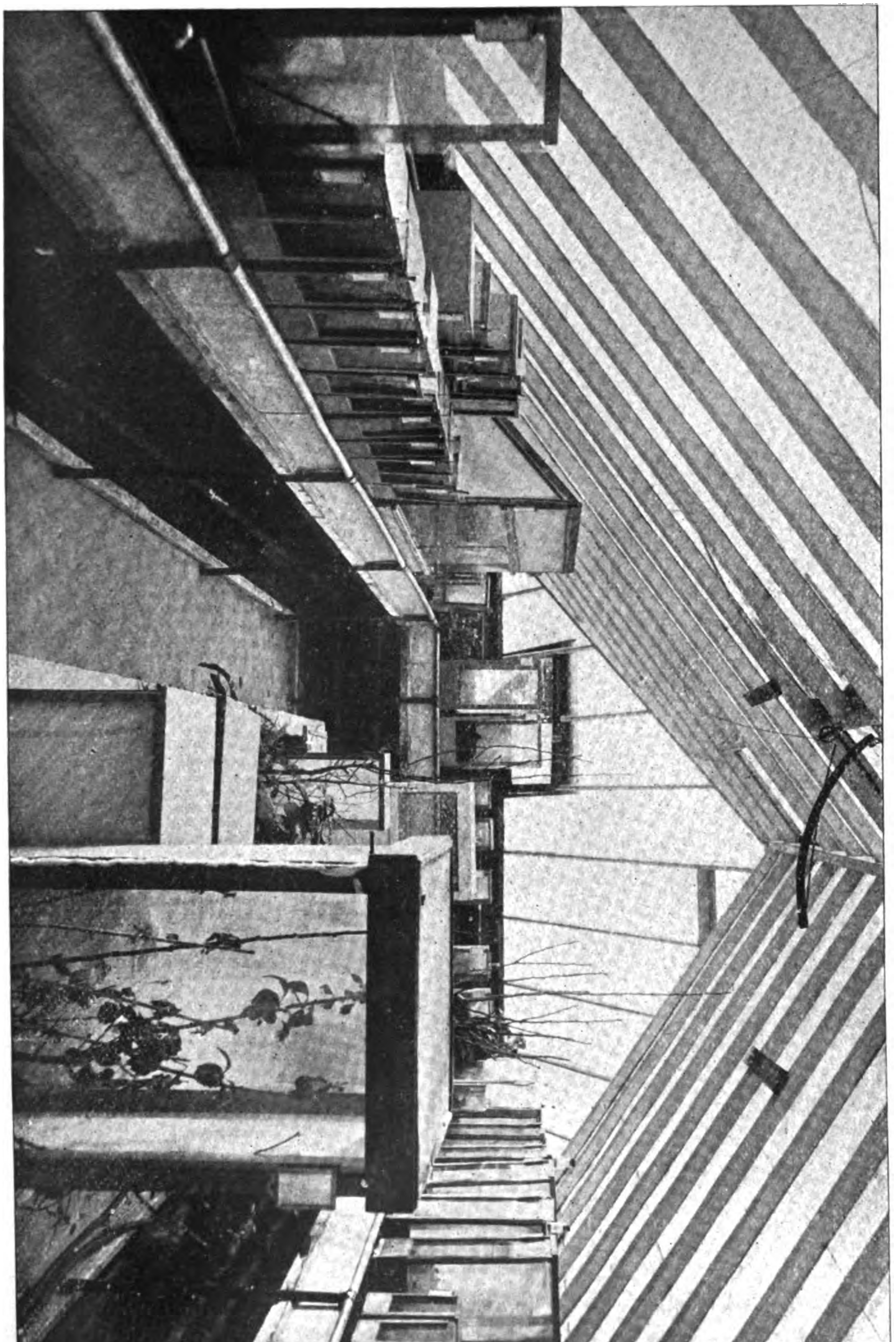
The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.

Bul. 113



Interior of Insectary showing construction of benches.

PLATE XIX.



Interior of Insectary showing completed benches and breeding cages in use.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 114. JANUARY, 1900.

HOW INSECTS ARE STUDIED AT THE OHIO AGRICULTURAL EXPERIMENT STATION.

PLATES XVIII, XIX.

BY F. M. WEBSTER.

The object in publishing this bulletin is to show the farmer and fruitgrower, who is unable to visit the Station and see for himself, just how we study insects, closely and accurately, and how the information thus secured is adapted to practical application in field, orchard or garden. This kind of investigation is too often looked upon as more technical than practical, as, indeed, it would be were it not for the fact that, sooner or later, it is all submitted to the crucial test of practical field application.

With the constantly increasing activity in applied entomology in America, the necessity for rooms or apartments especially adapted to the study of the development of insects is becoming each year more imperative. The insectary has, in fact, become almost as necessary to the working entomologist as has the laboratory to the chemist. While it is especially true in entomological investigations that one must "study nature where nature is," it is equally true that one cannot, in all cases, watch with the necessary care and constant application in the fields that he will be able to do in a fairly well equipped insectary. Not only can insects be transported thousands of miles, while in an inactive state, and their development watched at close range, as it were, but eggs and larvæ may be brought in during late autumn or winter, and studied through their various stages, frequently long before they have appeared outside; and in cases of uncommon or unfamiliar forms this will give the investigator a vast amount of information that he can use to great advantage when the species appears in the fields under natural conditions, perhaps months later. We are at present studying the onion Thrips in this way.

When any demand has arisen for certain facilities, in order to study

any particular species of insect, and this has constantly been the case, the ingenuity of myself and my assistant has been drawn upon to devise the best methods of accomplishing this end, and thus our insectary has come into existence.

Farmers will readily understand the impossibility of transporting a whole wheat field, or a whole meadow, across the state to Wooster, and there are few indeed who will not comprehend the difficulty of watching an insect in the field, closely, throughout the months of its life cycle.

Insects are more often destructive in the young or undeveloped stage, like caterpillars and grubs, and these young often have no more resemblance to the fully developed insects than a young wheat, corn or oat plant has to the kernel of these grains. For this reason, the young of insects must frequently be reared, just as many varieties of fruit trees must often be fruited before we can tell just what they are. Thus, the studies of injurious and beneficial insects are carried out closely in the insectary, and more widely in the field. Besides, we are often able to test remedial and preventive measures, in a small way, in the insectary, and frequently learn what will *not* be worth trying in the fields. It is well known that most insects have some weak point in their life, or, in other words, there is usually some phase of their development which, if understood, will give us an advantage in overcoming them. This we can frequently learn in the insectary. The insectary thus becomes a sort of a searchlight, to enable us to see more clearly in the fields.

The insectary, proper, is constructed much after the plan of an ordinary greenhouse ' The walls are made of hollow tile, and the movable sashes in the roof, for ventilating purposes, are enclosed in dormer-like, wooden frames, covered with swiss or a very thin cotton sheeting, in order to prevent the introduction or escape of the most minute insects. A door at one end opens into a workroom, while a window in the roof at the other end is provided with a protected, movable sash, like those previously mentioned.

Along three sides extends a bench, such as are in use among florists, except that, in this case, it is only about 30 inches in width, to facilitate the close examination of objects at the far side. A portion of the central space is occupied by a reservoir, where, originally, we had a wider bench.

Wooden benches were tried at first, but these soon decayed, while it is well known that the larvæ of many species remain long in the earth and to disturb them is fatal, so we were obliged to cast about for something more stable to meet these requirements. We are now using, with apparently perfect success, a bench, the construction of which is shown in Plate XVIII. The bottom is of ordinary stone flagging, two inches in thickness, and supported on a frame work made of ordinary gas pipe. The upper side of this flagging is deeply grooved, about an inch from the edge, along each side. For the back of the bench ordinary roofing

slate is used, the lower edges being fitted into the groove in the stone and embedded in cement, while the upper edges are held in place by a cap of galvanized iron, running along the entire length. For the front a heavy galvanized sheet iron is used, the lower edge, as with the slate, fitting into the front groove in the flagging, while the upper is drawn over and turned under the smaller, horizontal gas pipe, the latter being held in place by a T joint, all of which is shown in the background of Plate XVIII. Before filling the benches, the inside of the galvanized iron front is coated with asphalt.

The wider, central bench was discarded altogether and the space enclosed by a low brick wall, plastered with cement. This enclosed space is filled with earth and will accommodate shrubs and even small trees.

The finished benches, with the whole apartment in actual service, are shown in Plate XIX. Formerly, we placed soil in the breeding cages, and grew, or tried to grow, the food plants of whatever insects we happened to be studying therein; but the plants seldom thrive well under such conditions, and the effect on the insects feeding thereon is unsatisfactory and in many cases fatal. Especially is this true where it becomes necessary to transplant from out of doors, as it frequently occurs that we wish to transfer a plant with the larvæ feeding upon it, to a position that will enable the movements of the latter to be carefully studied. Under the new arrangement we can either grow the food plant in the benches, or transplant it from the garden or field, place our insects upon it, and cover with a breeding cage, thus eliminating to a considerable extent the objectionable features of the old method. Or, if we find an insect attacking a plant out of doors, we can place over the plant one of the cages, of the pattern that we are now using, and pushing the metal base into the soil, deftly inclose the whole within our cage without in the least disturbing the insects that we wish to study under the most natural conditions possible.

The breeding cage now in use is shown in Figure 1, and also in Plate XIX. It consists of a wooden frame of four upright pieces, supporting a wooden top, and with an upper base, also of wood. Three sides are covered with swiss drawn tightly and fastened along the edges with galvanized iron strips about one-fourth of an inch in width, and these are in turn fastened to the wood by tinned staples, such as are used in laying carpets and matting. The remaining side is of glass, which is raised and lowered as required, and works in vertical grooves. By using galvanized iron strips and tinned staples the rusting out of the swiss or other cloth covering is avoided. The lower base is also of galvanized iron, and is shown in Fig. 2, as is also the wooden bottom which fits inside of this. The latter can be used when needed, and when not may be readily removed and laid aside, as it is fastened in place by screws. When used without the bottom it is only necessary to place the cage

over the plant, or plants, and press it down until the metal portion is sunk into the soil. The cage can be used out of doors as well as in the insectary, and without materially affecting the plant or disturbing the

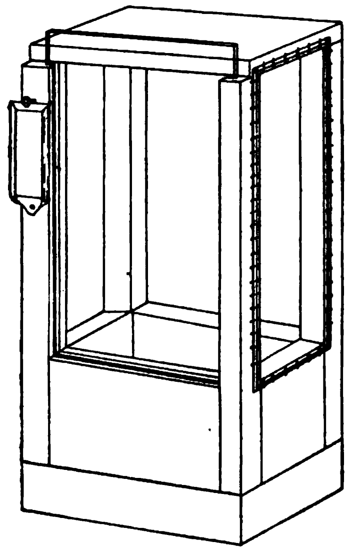


Fig. 1.

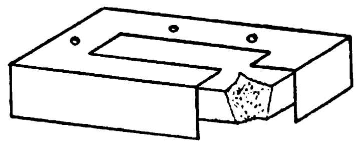


Fig. 2.

insects feeding upon it. When used with the wooden bottom the metallic base raises this above the damp soil, thus preventing the decay of the lower portion of the cage.

But "the one supply reveals another want," and we soon found that there was need of some method of keeping our notes and records conveniently attached to the proper cage to which they belonged, as well as to protect them from being wetted whenever the benches were wet down with the hose. This led to the use of a holder of galvanized iron, with a sliding glass front, fastened to the cages as shown at the left in Fig. 1, and also in actual use on the cages in Plate XIX. The holder is two by three inches, the sides turned over, and one end folded over these, while the other end is left a little longer and rounded, with a small hole to pass over a small nail or brad, while the folded end is held by a small screw-eye, such as are used on picture frames to which to attach the ends of the cord or wire. The note sheet is folded the proper size and placed in the holder, and the rather close-fitting glass slide pushed in over it. The sheet is so folded that all of the notes will come on the same side, and each space or page is consecutively numbered, and, being all of a uniform size, these sheets, when filled, or the record finished, can be filed away for permanent preservation. This holder cannot easily become detached from the cage to which it is fastened, the notes are preserved from being injured by wet, the galvanized iron does not rust them, and the last record can always be seen through the glass cover without

removing it from the cage. With slight modifications, this holder can also be used out of doors on shrubs and trees. For this purpose, what shows as the lower end in Fig. 1, is cut square off and a similar triangular piece is soldered to the back of the upper end, to accommodate a fine wire, which is used not only to attach the holder to the object, but the end running downward along the back is hooked over the lower end of the holder, thus effectually preventing the glass slide from being shaken out by the action of the wind. On cages outside it is of course used in the same way as in the insectary.

Let us suppose that Farmer A sends us some destructive worms that we do not recognize. As soon as these are received they are, perhaps, given a number, precisely as is a new convict when he reaches the penitentiary, only in this case instead of giving the recipients of this number a cell, they are given a breeding cage, like the one shown in Fig. 1, with a supply of food. In the book in which this number is recorded are spaces left for the name, when this is learned, date of sending, name and postoffice address of sender, with the number of letter file in which all of his letters relative to the insects sent are kept, as will be more fully explained. Thus, not only are his letters easily found, but all of the information that we possess relating to the insect sent can be brought together in a few minutes, and this can also be done fifty or a hundred years hence.

Regarding the material that comes into the insectary, this is, of course, derived from two sources: First, that of our own collecting, and which may come from all parts of the state; and second, that which is sent to us by correspondents, and which comes largely from the state in which we are located, but may come from almost anywhere. Such insects as do not require leafy plants upon which to feed, or such as have passed into the pupal stage and require no food, excepting such insects as are found in limbs and trunks of trees, we manage by the old method of keeping them in jelly glasses. For such as require a limited amount of food, and especially where we wish to watch their movements very closely, we use the ordinary glass cylinders, known as chimneys for the Argand gas burners. These are about two inches in uniform diameter and five inches in length. We find these preferable to ordinary lamp chimneys, as they are of better quality of glass and less easily broken. These can be placed over plants, either in the benches in the insectary, or when the plants are growing in ordinary flower pots. The top of the cylinder is covered with a thin muslin held down with glue or asphalt. Whatever preparation is used for this purpose should be insoluble in water.

For insects that require much food, and for which a large amount of leafage is consequently necessary, we employ larger breeding cages. We have certainly found it much more satisfactory to transplant food plants to the benches of the insectary, and better yet, where possible, to grow

these plants in such situations, as the food supply for the insects is thus in a more natural condition than can be made possible if the food is simply gathered and placed in the old-style breeding cage with an immovable bottom. Where possible to do so, I make it a point to grow food plants in the insectary, and thereby prevent the accidental introduction of other forms into our breeding cages which, very often are exceedingly annoying, and nearly or quite vitiate results that have cost much time and attention.

When material is brought into the insectary, it is seldom given an "accessions catalogue" number at first, but is placed in jelly cups or cages and a slip is attached thereto, giving date of reception and locality from which it came. In case nothing develops worth recording, then we have saved loading down our accessions catalogue with unnecessary numbers. But as soon as any developments are noted, as, for instance, the appearance of parasites, or the further transformation of any of the insects included, we then enter the material in the accessions catalogue, number it, and attach this number to the cup or breeding cage, as the case may be. As soon as the material is taken from the cages, or from the jelly cups, it is pinned and a label placed upon each pin, giving date of appearance and accessions catalogue number. If the material has come from elsewhere besides the Experiment Station, or immediate vicinity, the exact location, as nearly as we can obtain it, is indicated on the pin on the second label. That is, we would have on one label, "Insectary, 6-5-'99," which signifies that the specimen appeared June 5, 1899. Either above or below this label would be another, which might read, "Toledo, O., 1-4-'99," which would indicate that the material from which the specimen developed was obtained at Toledo, on the 4th of January, 1899. This prevents the confusion between the date of collection and the date of appearance of fully developed specimen. If, as is sometimes the case, material is placed out of doors and there reared in breeding cages, we then give the original locality and date of collection on one slip and on another the locality and date where it was reared, so that there will be no confusion between the two. It is expected that breeding cages and breeding cups will be carefully inspected, at least once each day, and everything that has reached a condition where it is ready for permanent preservation is removed, although it frequently occurs that cups or cages may have to be examined several times each day in order to prevent insects which are developing in them from becoming rubbed or otherwise injured by attempts to escape.

For the rearing of such insects as bore in wood, and their parasites, we have had a special cage made. This is much like the ordinary breeding cage, except that the top, bottom and three sides are of wood. The fourth side is provided with a movable front, and for this we use a very heavy glass, very thickly painted with asphalt, so that after we have placed sections of limbs of trees in the cage and closed the front, the

interior of the cage is entirely dark, excepting a very little light that is permitted to enter from a round hole made in the top of the cage, and over this we place one of the glass cylinders, previously named, the top of which is covered with muslin, as has been described. These glass cylinders are held in place by small spiral springs, made of brass wire, and arranged in such a way as to inclose the lower end of the cylinder about an inch from the end, the springs being held in place by small nails. By this means all insects that develop in the cage below on seeking the light make their way upward out of the cage and into the glass cylinder from which they cannot escape, but wherein they may be easily detected. When we wish to remove them we simply raise the cylinder slightly and push a bit of cardboard beneath it, thus shutting off the escape of the insect, and, by injecting a few drops of chloroform into the cylinder and covering the top, kill them almost instantly without in any way affecting the atmosphere in the compartment below. These cages are quite convenient, as they may be placed almost anywhere on a shelf or similar place, and it is only necessary to inspect the glass cylinders in order to determine whether or not anything has developed from the sections of wood beneath.

The accessions catalogue has been arranged in a way that, so far as known to me, is largely original. The left-hand page is divided into seven columns, each of which is filled out after the following manner:

The first, or the one nearest to the outer margin, is used to indicate the number of the bulletin in which the information relating to the species has been published, when this has been done; the second space contains the accessions catalogue number; the third space indicates the number and page of the journal containing the further records relating to the species; fourth, the name of the species; fifth, the locality from which it came; sixth, date of collection or of sending, if it has been sent us by a correspondent; seventh, name of collector, or sender. This occupies the entire left-hand page, while the right-hand page is divided into two spaces only. The first, or the one on the left, is quite narrow and contains the number of the letter file in which the letter accompanying the specimens, if sent by a correspondent, is filed, the remaining space being devoted to remarks, which include any short item that can be expressed in a very few words. All additional information outside of this is taken to the journal, and its position in the journal is indicated in the third space from the margin on the left-hand page, as previously stated. When the breeding notes are finished and revised they are transferred to the journal, as every one knows that original notes, in order to be of value, must contain a great deal that it is not usually necessary to use in print. In other words, the journal is supposed to contain the essential facts obtained regarding the species, together with such details as seem of sufficient importance to include.

The journal is arranged in this manner: Starting at the top of the

page, first will be given the accessions catalogue number; following it on the upper line the food plant or other host, if such is known, followed by the name of the species, if we have it, and if parasitic the fact is also indicated. Below this is given the date of observation, and following this the note itself. It will be seen that by this means we are able not only to gather together all of the material relative to a single species, but also our own notes and records, even to the original slips that we have recovered from the cages or jars. Besides this, we can at once find not only the original letters from the parties sending us the material, but any replies we have previously made thereto. As I stated before, this sytem requires considerable book-keeping; but when we come to use our notes and correspondence, as well as to refer to the material, we find that it is but a very simple task to get it all together, and we here save much more time than we have expended in keeping our records.

In both our collections and breeding we aim, as much as possible, to get the exact locality from which the material came. Here, again, I have found considerable difficulty. Often a farmer may live anywhere from one to ten miles from his postoffice, and in these cases it is of course absolutely impossible to give exact localities, as his farm may lie several hundred to a thousand feet above his postoffice town, or the reverse may be true. The only way I have found to in part obviate this difficulty is to have a map of the state, showing not only the counties but the townships! mounted upon a back of thick board or plank of seasoned pine. With this mounted upon an easel near my desk, I have spread out before me the whole state. Then, if I can get a correspondent to tell me in what township he lives, and in what part of this township, I can get his location almost exactly. This map is exceedingly convenient in following out the spread or distribution of any species, as wherever it is discovered by either myself or my assistant, or wherever it is reported by our correspondents, we indicate the exact locality on our map by a small disk of colored paper, using different colored disks for different species of insects. In this way we can not only indicate in a very clear manner the spread of the species over the state, year after year, but we can also indicate the extent of more or less local outbreaks; as, for instance, in studying the distribution of the seventeen-year cicada in 1897, we used a small disk made from canceled 2-cent postage stamps, and wherever the cicada were observed or reported in a locality, we marked that locality by one of these disks, fastened to the map by a small tack. At the end of the season we have the entire distribution, so far as we are able to obtain it, directly before us, and have but to sketch this area on a base map, by the use of oblique lines, to get a drawing ready for the engraver. Again, as illustrating the second use, that of indicating local outbreaks, of course, there is the first report to go on. This will be indicated on our map by a single colored disk. If there is much destruction

and the outbreak extends over any considerable territory, we shall very soon hear from a greater or less number of people within this area of destruction, and by indicating the location of these on our mounted map, we will, within a few days, be able to see at a glance just where the trouble is being experienced. In other words, we have the storm center, as a meteorologist would express it, indicated clearly upon our map. This takes but very little time, and I have found it a very great help, either in keeping track of the spread of insects that are known to be moving in some particular direction, or in showing the area covered by the outbreak of any pest. While it requires a little time to attach these colored disks, I think that this is more than saved when I come to prepare a drawing for the engraver, showing the area over which any species has extended or become seriously destructive. I do not know whether this scheme of mapping outbreaks and diffusions could be carried out on a larger scale on the United States map, but it seems to me that it could be used in such cases also, though perhaps in a more general way.

As before indicated, we look upon this work as preliminary to that carried out in the fields, where we have to encounter the same conditions as the farmer, and, therefore, we are enabled to give him the combined results of insectary and field experience and investigation. Not only this, but every fact that any farmer has given us is brought to bear on the problem to which it may relate, and thus all get the benefit. In other words, it is a mutual object lesson, wherein all information gained from any quarter is taken to the fields of the farmer and there before his own eyes he can see what is done, how it is done, and just what results are obtainable under the same conditions as he himself labors. Every one understands, perfectly well, the difference between having a method explained to him and seeing the method carried out. We can only investigate insect depredations in the localities where these occur, but we can and do very often, in the insectary, get information that enables us to take a short cut, so to speak, when we go to the fields to carry out this work.

Ohio Agricultural Experiment Station.

BULLETIN 115.

WOOSTER, OHIO, JANUARY, 1900.

SUGAR BEETS AND SORGHUM.

INVESTIGATIONS IN 1899.

The Bulletins of this Station are sent free to all residents of the State who request them.
All correspondence should be addressed to

EXPERIMENT STATION, WOOSTER, OHIO.

COLUMBUS, OHIO
FRED J. HEER, STATE PRINTER
1900

ORGANIZATION OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

BOARD OF CONTROL.

R. H. WARDER	North Bend
J. T. ROBINSON	Rockaway
HON. L. M. STRONG	Kenton
THE GOVERNOR OF THE STATE THE DIRECTOR OF THE STATION	*Ex officio*

OFFICERS OF THE BOARD.

J. T. ROBINSON	President
R. H. WARDER	Secretary
PERCY A. HINMAN	Treasurer

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CHARLES E. THORNE	Wooster	Director
WILLIAM J. GREEN	"	Horticulturist and Vice-Director
J. FREMONT HICKMAN, M. A. S	"	Agriculturist
FRANCIS M. WEBSTER, M. S.	"	Entomologist
AUGUSTINE D. SELBY, B. Sc	"	Botanist and Chemist
PERCY A. HINMAN	"	Bursar
JOHN W. AMES, B. Sc	"	Assistant Chemist
JOHN F. HICKS	"	Assistant Botanist
WILMON NEWELL, M. Sc.	"	Assistant Entomologist
WILLIAM HOLMES	"	Foreman of Farm
CHARLES A. PATTON	"	Ass't Foreman and Meteorologist
ANNIE B. AYRES	"	Mailing Clerk
CARY WELTY	"	Mechanic
EDWARD MOHN	Strongsville	Supt. Northeastern Sub-Station
LEWIS SCHULTZ	Neapolis	Supt. Northwestern Sub-Station

The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final numb r of each yearly volume.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 118. JUNE, 1900.

FIELD EXPERIMENTS WITH WHEAT.

BY J. FREMONT HICKMAN.

INTRODUCTION.

The investigations reported in detail upon the following pages cover the work of three full seasons, and will include the yearly comparison of a list of varieties for the seasons of 1897, '98 and '99, together with some cultural investigations for each of the years. The work very naturally divides itself into two general parts. I, Comparison of varieties and II, Cultural investigations.

COMPARATIVE TESTS OF VARIETIES OF WHEAT.

Since the Station began its work at the present permanent location these variety tests have been made in one field, which is divided into five sections, each section giving room for ninety tenth-acre plots. This is known as "Variety Field" and the five sections permit a five-year rotation, which has been strictly followed, beginning with the fall of 1893. This rotation consists of corn, oats, wheat, clover and timothy, in the order named. These variety tests are based upon uniform conditions of drainage, cultivation, seeding, harvesting and threshing. The drainage was amply provided for early in the work, by laying a tile drain on one side of every plot, at a uniform depth of two and one-half feet. The plowing, harrowing and other cultivation of the ground is made uniform by working crosswise of the plots. This leaves the work at the close of any day with as much work completed upon one plot as upon any other.

Commercial manures have never been used, but a top dressing of yard manure is applied across the plots with a manure spreader, before

REPORT OF THE TREASURER.

To HON. J. T. ROBINSON, *President of the Board of Control:*

SIR: I respectfully submit herewith the financial report of this Station for the fiscal year ending June 30, 1900:

In Statements A, B, C and D, respectively, will be found a record of the receipts and expenditures from the various funds; Statement A being a statement of account with the annual appropriation received from the U. S. Treasury, and a copy of the report made to the Governor of the State, the Secretary of Agriculture and the Secretary of the U. S. Treasury; Statement B being a statement of account with the State Treasury; and Statement C showing the receipts and expenditures from farm produce and other sales.

The three statements, A, B and C, are combined in Statement D, which shows the total income and expenditures for the fiscal year.

STATEMENT A.

THE OHIO AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATION, 1899–1900.

Dr.

To receipts from the Treasurer of the United States, as per appropriation for the fiscal year ending June 30, 1900, as per act of Congress approved March 2, 1887		$15,000 00

Cr.

By expenditures for:—		
Salaries	$12,073 10	
Labor	1,310 27	
Postage and stationery	69 27	
Publications	13 13	
Heat, light and water	305 96	
Seeds, plants and sundry supplies	534 27	
Fertilizers	4 56	
Feeding stuffs	323 33	
Library	77 05	
Tools, implements and machinery	165 57	
Furniture and fixtures	20 03	
Scientific apparatus	4 28	
Contingent expenses	10 00	
Building and repairs	89 18	
		$15,000 00

I, the undersigned, duly appointed Auditor of the Corporation, do hereby certify that I have examined the books and accounts of the Ohio Agricultural Experiment Station for the fiscal year ending June 30, 1900, that I have found the same well kept and classified as above and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000.00, and the corresponding disbursements $15,000.00; for all of which proper vouchers are on file and have been by me examined and found correct.

And I further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

{ SEAL OF INSTITUTION }

Signed,
J. T. ROBINSON,
Auditor of Board of Control.

Attest: CHAS. E. THORNE, *Custodian.*

I hereby certify that the foregoing statement of account to which this is attached, is a true copy from the books of account of the institution named.

P. A. HINMAN,
Treasurer of Board of Control.

STATEMENT B.

OHIO AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE STATE TREASURY.

Date of appropriation.	Appropriation for—	Total amount to the Station's credit.	Total amount expended.	Balance in treasury June 30, 1900.
1900	Expenses of the Board of Control......	$500 00	$217 84	$282 16
	Sub-stations for field experiments.......	2,200 00	441 85	1,785 15
	Bulletin illustration	400 00	123 27	276 73
	Special work in entomology, botany, horticulture and chemistry..........	3,500 00	631 21	2,868 79
	General repairs, labor and supplies......	3,000 00	2,949 17	550 83
	Investigation of tuberculosis, and other diseases of cattle..................	3,000 00	....	3,000 00
	New construction	4,850 00	....	4,850 00
	Totals for 1900..................	$17,950 00	$4,363 34	$13,586 66
	Balance of appropriations for 1898 and 1899 brought forward July 1, 1899..			
1898	Expenses of the Board of Control......	$362 97	$199 54	....
		....	....	*163 43
	Bulletin illustration	443 65	443 65	....
	Special work in entomology, botany, horticulture and chemistry..........	146 41	146 41	....
	Investigation of tuberculosis............	124 61	124 61	....
1899	Expenses of the Board of Control.......	300 00	300 00	....
	Sub-stations for field experiments.....	2,298 35	2,298 35	....
	Bulletin illustration	400 00	400 00	....
	Special work in entomology, botany, horticulture and chemistry	3,000 00	3,000 00	....
	General repairs, labor and supplies......	852 16	852 16	....
	Totals	$25,879 15	$12,129 06	$13,586 66

* This amount lapsed to the State Treasury.

In addition to the above amounts appropriated for the use of the Experiment Station, the amount of $15,000 has been appropriated to the

Board of Control of the Experiment Station for the State fiscal years 1900 and 1901 for the enforcement of the law providing for the inspection of nurseries and orchards, the text of which is given in the appendix to this report. Of this amount $171.86 was expended prior to June 30, 1900.

STATEMENT C.

OHIO AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE PRODUCE FUND.

To Receipts:—

June 30, 1900.		
From sales of agricultural produce	$1,788 67	
" dairy produce	496 84	
" live stock	1,010 06	
" horticultural produce	1,486 59	
" botanical produce	9 98	
labor	164 09	
rents	917 00	
miscellaneous sales	487 15	
fees for testing dairy cattle (milk test)	149 20	
fees for inspection of nurseries	172 87	
fees for chemical anaylsis	55 00	
Northeastern Sub-station	94 88	
Northwestern Sub-station	132 49	
Total receipts for the year		$6,964 82
To balance brought forward July 1, 1899		832 06
Total		$7,796 88

By Expenditures:—

June 30, 1900.		
For labor	$3,705 44	
postage and stationery	33 07	
freight and express	217 75	
heat, light and water	172 28	
seeds, plants and sundry supplies	657 49	
fertilizers	27 56	
feeding stuffs	12 78	
library	164 88	
tools, implements and machinery	217 16	
furniture and fixtures	2 10	
scientific apparatus	1 20	
live stock	300 40	
traveling expenses	38 19	
contingent expenses	34 10	
building, repairs and farm improvement	419 62	
miscellaneous	408 14	
Total expenditures for the year		$6,412 16
By balance carried forward		1,384 72
Total		$7,795 88

STATEMENT D.

TOTAL RECEIPTS AND EXPENDITURES OF THE OHIO AGRICULTURAL EXPERIMENT STATION FOR THE YEAR ENDING JUNE 30, 1900.

Total Receipts:—

From U. S. Treasury	$15,000 00	
State appropriations	17,950 00	
miscellaneous receipts	6,964 82	
Total receipts for the year		$39,914 82
To balance brought forward July 1, 1899		8,761 21
Total		$48,676 03

Total Expenditures:—

For salaries of technical and office staff		$12,009 23	
special and temporary services		10 00	
foremen and skilled laborers	$3,416 44		
ordinary labor	6,122 24		
Total labor		9,538 68	
publications		1,047 17	
postage and stationery		440 00	
freight and express		472 58	
heat, light and water		669 16	
chemical supplies		143 01	
seeds, plants and sundry supplies		1,983 67	
fertilizers		152 68	
feeding stuffs		946 92	
library		394 05	
tools, implements and machinery		867 21	
furniture and fixtures		22 13	
scientific apparatus		284 11	
live stock		550 40	
traveling expenses		1,565 84	
contingent expenses		351 23	
building, repairs and farm improvement		1,685 01	
miscellaneous		408 14	
Total expenditures for the year			$33,541 22
By balance, expenses of Board of Control, lapsed			163 43
By net balance carried forward			14,971 38
Total			$48,676 03

Respectfully submitted,

P. A. HINMAN, *Treasurer.*

REPORT OF THE DIRECTOR.

REPORT OF THE DIRECTOR

HON. J. T. ROBINSON, *President of the Board of Control:*

SIR: I have the honor to submit herewith the nineteenth annual report of this Station, it being my thirteenth report as Director.

INSPECTION OF NURSERIES AND ORCHARDS.

The last General Assembly of the State enacted a law intended to prevent the introduction and spread of San José scale, black knot, peach yellows, "and other dangerous insects, and tree, shrub, vine or plant diseases;" the full text of which is given in an appendix to this report. The execution of this law has been laid upon the Board of Control of this Station. Since the work thus provided for is merely police work no part of it can be legally supported from the fund given by the National Government to the State for purposes of investigation. It therefore becomes necessary to so organize the work that it shall be clearly separated from the scientific research which is the only work authorized by the National law under which this Station is organized.

BOVINE TUBERCULOSIS.

The confidence of the General Assembly in the Experiment Station was strikingly shown by the unsolicited addition of an item to the general appropriation bills, appropriating to the Station $3,000 each year for 1900 and 1901 "For investigation and prevention of tuberculosis and other diseases in cattle, throughout the State of Ohio."

No other responsibility ever laid upon this Station has exceeded this in importance; for the action is the outcome of the growing conviction, on the part of those best qualified to judge, that tuberculosis in cattle plays an important part in the diffusion and perpetuation of this deadliest scourge of the human race.

This problem of the prevention and control of bovine tuberculosis is being attacked, throughout the civilized world, by men who are bringing to bear upon it the highest ability and the most elaborate training in the methods of modern scientific research. It is a many sided problem, and there is work to be done in field and stable as well as in the laboratory, and especially is there work to be done on the minds of men, in arousing them to a true appreciation of its importance; but unless all this work, that conducted in field and stable as well as the

most elaborate laboratory research, and especially that which aims to put the results of these researches before the people, be actuated by the scientific spirit, which is simply the spirit of truth illumined by the ripest human knowledge, and which is equally far from exagerration and from underrating, then it would better not be undertaken at all.

INVESTIGATIONS OF THE YEAR.

THE MAINTENANCE OF FERTILITY.

Bulletin 110 (91 pp, 10 plates) contains a more complete report of the Station's work on this problem than had previously been made. This report contains not only a résumé of most of the field experiments thus far made, but also a study of the soils on which these experiments are located, in respect to their mechanical and chemical composition; this part of the work having been executed by the Chemical department of the Station.

While chemical analysis has not yet reached the point of serving as a reliable guide to the fertilizing of the soil, yet it offers useful suggestions in that direction. Certainly the more fully we understand the physical and chemical composition and the geological history of our soils the more intelligently we can treat them.

This combined field and laboratory study of the soil is bringing out results which strongly emphasize the need of further work in this direction. This is one of the richest states of the Union in mineral wealth; but the value of the annual product of Ohio's farms and orchards is more than six times that of the combined annual output of all her mines of coal and iron, all her wells of oil and gas, and all her quarries of stone. But there has as yet been no attempt at a systematic study of the soils of the state, such as that given to its mineral resources.

ANIMAL HUSBANDRY.

Bulletin 117 (14 pp, 1 plate) reports a series of experiments in the treatment of sheep for the stomach worm, *Strongylus contortus* (Rud.) including an apparently successful experiment in prevention by keeping the animals housed until after the season for this parasite has passed.

The correspondence of the Station shows that the benzine or gasoline remedy for this pest, first suggested by Prof. Ch. Julien, of the Agricultural Experiment Station at Grignon, France, is being more and more widely used and with generally favorable results when properly employed.

The Station herd of cattle has apparently been brought to the condition of perfect health by the methods employed to rid it of tuberculosis three years ago. Since that time the tuberculin test has been applied regularly every six months to the entire herd. There have been three cases of reaction, which were promptly disposed of; but whereas there were frequent deaths in the herd from obscure causes before the final

cleaning out under the tuberculin test in the spring of 1897, no such cases have occurred since that date.

An experiment in feeding for beef was made during the winter, but its results have not yet been published.

CEREAL CROPS.

Bulletin 118 (26 pp) carries forward to 1899 the report of the variety and cultural tests of wheat, which have been a prominent feature of this Station's work. These tests continue to indicate a high rate of productiveness in the Mealy wheat, a distinct variety sent to this Station by the National Department of Agriculture several years ago. The high rate of yield of the Poole wheat continues to be maintained.

The almost unprecedented destruction of the wheat crop of 1899-1900 by the combined influence of Hessian fly and winter killing is a matter of great consequence in a state where the wheat crop occupies so important a position as in Ohio. The Station's experiments strongly indicate that the remedy for both these sources of loss lies in a more thorough and intelligent attention to the maintenance of fertility. On land depleted by exhaustive cropping, including even the rotative cropping practiced on many farms, on which three or four crops of cereals are taken from the land before any attempt is made at recuperation through clover or manure, the crop was almost totally destroyed; but where similar land was under shorter rotations with systematic manuring a fair yield was obtained, while on land that had never been depleted of its fertility the yield rose to 40 bushels per acre.

HORTICULTURE.

Bulletin 113 (13 pp, 5 plates) reports a comparison of varieties of plums, selecting from the Station's list of about 175 varieties those which had come into bearing by 1899.

The Station's orchards are justifying the care which has been given them by the large crops of fine fruit on the older trees and by the healthy foliage and strong growth of the younger ones.

ENTOMOLOGY.

Bulletin 112 (7 pp, 1 plate) is a report on the clover root borer. Bulletin 114 (9 pp.) is a description of the methods of insect study at the Station; Bulletin 116 (4 pp, 1 plate) is a report on the grape-cane gall-maker and its enemies, and Bulletin 119 (9 pp, 1 map) is a report on the Hessian fly.

BOTANY.

Bulletin 111 (50 pp, 8 plates) is a summary of the work of this Station, from 1891 to 1899, in the control of diseases of plants. This bulletin reviews in detail the earlier work of this Station on apple scab, work which has demonstrated the practicability of controlling this

destructive fungus, and treats more briefly on subsequent work on other fungous diseases of plants, including especially the leaf curl of the peach.

CHEMISTRY.

Bulletin 115 (18 pp) is a report on the continuation, through 1899, of the sugar beet and sorghum investigations, made during previous seasons in coöperation with the U S Department of Agriculture on the one hand and with farmers on the other, for the purpose of studying the possibility of introducing these crops in Ohio. As already stated, the chemical department of the Station has made a series of analyses of the soils upon which the field experiments of the Station with fertilizers are being conducted, a work involving several months of exacting labor.

The foregoing summary of the Station's publications gives a general view of the character of its work. The different lines of investigation may be grouped as follows:

1. Study of the soils of the Station and of the State, with reference to their physical and chemical composition and to the cultural and fertilizing methods best calculated to conserve moisture and fertility.

2. Study of crops, including grains, forage crops, fruits and vegetables, with reference (a) to the relative usefulness of different varieties, (b) to cultural methods and (c) to the growth habits of different species.

3. Study of the diseases affecting crops, including rusts, smuts, mildews, bacterial diseases, etc.

4. Study of the habits of injurious insects and of measures for their control.

5. Comparison of different breeds of cattle and sheep with reference to their relative value for different purposes.

6. Researches in the nutrition of animals, including the relative value of different foods, contrast of different methods of feeding, and study of the assimilative process of different individuals.

7. Investigation of the diseases of animals.

COÖPERATIVE WORK.

COOPERATION WITH THE NATIONAL DEPARTMENT OF AGRICULTURE.

In the execution of its work the Station has had invaluable assistance from the National Department of Agriculture. Through the Section of Seed and Plant Introduction of that Department the Station has received seeds of sugar beets, sorghum and many other varieties of plants, some of which have proven to possess great merit. As has been stated above, the "Mealy" wheat, which we consider one of the most valuable varieties on our list, was first distributed by the National Department. The Botanical Division has furnished the Station with several hundred samples of weed and other seeds, very valuable for purposes of identification. The Chemical Division has rendered assistance in the analysis of sugar beets. The Bureau of Animal Industry has furnished frequent install-

ments of tuberculin for use in coöperative researches in bovine tuberculosis. While the investigations of sugar beets and sorghum and of bovine tuberculosis are the only lines of this work which may be called strictly coöperative, yet all the divisions of the Department have been called upon for assistance, which has always been promptly and courteously rendered. In fact, the relations between the Department and the Station are such that but few days pass without a communication of some sort passing between the two institutions.

This statement of the service rendered to the work of agricultural investigation by the National Department of Agriculture would be incomplete without reference to the work of the Office of Experiment Stations. This office stands as the representative of the Secretary of Agriculture in his relation to the Experiment Stations. Its chief functions are to protect from misuse the fund given by the General Government for research in agriculture, known as the Hatch fund; to serve as a bureau of information for the stations regarding agricultural research in this and other countries, and to aid them in their work by advice and counsel.

The work of this office has thus far been administered with exceptional tact and fidelity. It has prevented flagrant abuses of the Hatch fund, and its publications are of great value to station workers and others. This is especially true of the "Experiment Station Record," a serial publication in which are given abstracts of the publications of all American experiment stations and titles of the publications of similar institutions in foreign countries. The work of this office could be largely extended on present lines with very great benefit to the cause which it represents.

COOPERATION WITHIN THE STATION.

In the studies of soils, of plant growth and of animal nutrition above mentioned the Agriculturist, Horticulturist and Chemist of the Station are working in close coöperation; many of these problems can be attacked successfully only through the field or stable; others only through the chemical or biological laboratory; but, for the final and successful solution of all, the microscope must follow the plow, and the delicate balance of the chemist must supplement the wagon scales.

The Chemist and Botanist of the Station is the Experimentalist of the Agricultural Student's Union of the State; and through this organization numerous lines of investigation are carried on by coöperation between the Station and farmers scattered over the State.

COOPERATION BETWEEN STATIONS.

While there is no organized coöperation between the different stations, nor any formal agreement as to division of labor, yet in actual practice much the same results are attained as would be reached by such agreement. The wide differences in soil and climate and in other

agricultural conditions of the different states necessarily involve similar differences in the leading objects of investigation pursued by the different stations.

It is a matter of course, for instance, that the Louisiana Station should lead in the matter of sugar production; that cotton culture should absorb the chief attention in the stations within the [illegible] belt; that wheat and corn should claim the precedence in the latitude of Ohio; that Wisconsin should specialize in the direction of dairying; that irrigation problems should be of chief interest in the arid regions, and that the conservation of soil fertility should occupy a leading place in the older agriculture of the eastern states. But where several stations, located in regions having greater similarity of conditions, undertake similar lines of research the result is not the waste of effort which some have predicted, but a more speedy attainment of the end in view. A few of the many results of work of this character are the practically universal use of the Babcock test for milk fat, following the repeated demonstrations of its value by various stations; the general adoption of the spray pump as an indispensable factor in fruit production; the introduction of subwatering in greenhouse management; the world wide acceptance of the tuberculin test as the most reliable diagnostic in bovine tuberculosis.

THE RELATION OF THE STATION TO THE AGRICULTURE OF THE STATE.

It is the function of the Experiment Station to gather suggestions from all quarters; to put these to test under the conditions of agricultural practice which prevail within its special environment, and to place the results of its investigations before the farmers of the State. One of the ways in which these results are made most directly available to the farmer is through personal correspondence and in such correspondence about 10,000 letters are written annually at this Station in answer to inquiries on special points, while many hundreds of similar answers are given verbally to persons who come to the Station for information, sometimes from considerable distances.

Another medium through which the Station's work is effectively brought before the people is the Farmers' Institute, and this channel of communication has been regularly employed by the members of the Station staff. The demand for help at these institutes, however, has become so great as to necessitate a curtailment of the time given to this work, in order to avoid a too great interference with the research work of the Station.

The fact that the assistance of the Station is sought in the directions indicated in constantly increasing measure is sufficient evidence that the farmers of the state are finding this assistance to be practically helpful to them in their work.

Following are some of the points in which the Station's work is being turned to practical use by the farmers of the State as shown by their testimonials:

As the result of the Station's field experiments farmers are becoming acquainted with the general principles upon which rational fertilizing depend, and are learning to purchase their fertilizing materials at a great saving of cost.

The variety tests of the Station give early and reliable information regarding the relative merit of newly introduced sorts, and many farmers and horticulturists have learned to watch the Station's work and to wait for the result of these tests before investing their money in the highly lauded "new" varieties that are annually put upon the market.

No line of the Station's work has been of greater immediate value to the farmer and fruit grower than the prevention of fungous diseases of plants. In the subduing of apple scab alone several commercial orchardists have testified that the Station's advice to them has been worth hundreds of dollars in single seasons, and similar testimony has been given with reference to the value of that advice in the prevention of vegetable mildews and blights.

Many farmers have testified to having received material aid in combatting the chinch bug from the Station's distribution of chinch bug fungus, and in general a better understanding of the methods of insect control is manifest.

The advice of the Station is frequently sought with respect to selections of breeds of cattle and to the value of different feeding stuffs.

Many testimonials have been received as to the efficiency of the benzine treatment for stomach worms in lambs, first published in America by this Station.

In this case, as in many others, the Station's work has been secondary to that of some other original investigator; yet oftentimes such work is absolutely essential to the practical utilization of the original discovery. The Station which limits its work to original research, without any attempt at the verfication of the work of others, will fall far short of its possible usefulness.

THE OPPORTUNITIES FOR POST-GRADUATE WORK AT THE STATION.

During the present season two college professors have spent some time in the pathological and chemical laboratories of the Station, pursuing special lines of investigation, and frequent applications are made for employment in some of its departments, by young men or women who desire to avail themselves of its opportunities for advanced study.

In all cases where the privileges of the Station's laboratories are granted the recipient is required to render some compensation, in the form of expert service or otherwise, and in occasional instances it has been possible to make arrangements for the employment of advanced students on terms mutually beneficial to Station and student.

I believe that the time has come when steps should be taken looking toward the organization of a system of student assistance, under which certain portions of the technical work now required at the Station might be done by post-graduate students, working under the immediate supervision of the department chief.

ACKNOWLEDGMENTS.

The following publications have been received during the year as donations to the Station's library, or in exchange for its bulletins:

BOOKS, PAMPHLETS AND SCIENTIFIC PERIODICALS.

Agricultural Experiment Stations: The bulletins of all the experiment stations of the United States and Canada are regularly received. Cloth-bound reports have been received from the following stations:

Connecticut State Station, annual report for 1899. Illinois, Bulletins 37-48. Kansas, 12th annual report, 1898-99. Louisiana Geol. Survey, Part V, Rept. for 1899. Maine annual report for 1899. Massachusetts, Hatch Station, 1898. Michigan, annual reports for 1898 and 1899. Minnesota, annual report for 1899. New York State Station, annual report for 1898. North Carolina, annual report for 1897-8. Vermont, annual report for 1899. Wisconsin, annual report for 1899.

Academy of Science of St. Louis, Dr. G. Hambach, Librarian, Washington University, St. Louis, Mo. Transactions for 1899-1900.

Agricultural education in Great Britain: Report on grants for, in the year 1898-99, by P G. Cragie, Secretary to the Board of Agriculture.

American Museum of Natural History, Central Park, N. Y., City; Bulletins.

Argentine Demonstracion Grafica de la Cosecha 1898-99 en la Republica Argentina. Hecha por el Ingeniero Agronomo Jose Cilley Vernet, Buenos Aires.

Barbados: Reports of the results obtained on the experimental fields at Dodd's Reformatory, 1898 and 1899, by J. P. d'Albuquerque, Island Professor of Chemistry and Agricultural Science, and J. R. Bovell, Superintendent of Botanical Station.

Bessarabia: The most injurious insects of tobacco in, by K. Lindeman. (Type written copy, translated.)

Bussy Institution of Harvard University: Bulletin No. 38, "The Basket Willow."

California State Board of Horticulture: Investigation of the California Olive Industry.

California State Board of Trade, G. A. Dennison, Secretary, San Francisco: Annual Reports.

Canada: Geological and natural history survey; Catalogue of Canadian plants, by John Macoun; 5 parts

Canadian Northwest Territories: Annual report of the Department of Agriculture for 1899 and bulletins. Hon. G. H. V. Bulyea, Commissioner of Agriculture. Regina.

Chicago Academy of Science: Annual report for 1897; The mollusca of the Chicago area.

Cincinnati Society of Natural History: Journal.

Columbus Horticultural Society, Homer C. Price, Secretary, Columbus, O. Reports.

Ecole Nationale d'Agriculture de Montpellier, France. Sur le Parasitisme du Phoma Reniformis, par MM Ravaz et Bonnet; Produits de la Vigne, par M. L. Ravaz; Les Systemes de Taille appliques a la Vigne, par M. L. Ravaz.

Finland: Ueber die Weissährigkeit der Wiesengräser in Finland, von Enzio Reuter, Helsingfors.

Formaldehyde as a Milk Preservative, by A. B. Young, M. D., Secretary State Board of Health, Augusta, Maine.

German Kali Works, N. Y. City; Reports of German experiments in the use of fertilizers.

Halle: Zehnter Jahresbericht der Versuchstation für pflanzenschutz, 1899; Landwirtschaftliche Jahrbücher, 1899; Untersuchungen über die Zweckmässigste Form der Kombination von Kupferhaltigen Fungiciden mit Seifenlaugen, von Dr. M. Hollrung.

Hamburg: Bericht über die Thätigkeit der Station für Pflanzenschutz im Jahre 1898-99. Dr. C. Brick, Director.

Hamburg: Bericht über die Thätigkeit der Station für Samencontrole 1897-98; Dr. A. Voigt, Director.

Hawaiian Experiment Station, Honolulu, Hawaii, Walter Maxwell, Director: Report for 1899.

Illinois Horticultural Society, L. R. Bryant, Secretary: Transactions for 1899.

Indiana Geology and Natural Resources, W. S. Blatchley, State Geologist, Indianapolis. 24th Annual Report, 1899.

Jamaica Botanical Department: William Fawcett, Director: Bulletins.

Java: Collection de la Station Experimentale pour l'industrie sucriere dans l'ouest de Java a Kagok-Tegel, pour l'exposition universelle de Paris, 1900. Verslag over 1899 van het Proefstation voor Suikerriet in West-Java, te Kagok-Tegel. De Riet-Schorskever *Xyleborus perforans* Wollaston door Dr. L. Zehtner; Mededeelingen van het Proefstation voor Suikerriet in West-Java te Kagot-Tegal.

Kamehameha Manual Training School, Hawaii: Bulletins of Department of Agriculture, by Thos. T. Sedgwick.

Kansas State Board of Agriculture, F. D. Coburn, Secretary, Topeka: Quarterly Bulletin on "Forage and Fodder."

Kansas State Horticultural Society, Wm. H. Barnes, Secretary, Topeka: Transactions for 1899.

Maine State Board of Agriculture, B. Walker McKeen, Secretary, Augusta: Bulletins for 1899-1900.

Massachusetts State Board of Agriculture, James W. Stockwell, Secretary; Annual Report for 1899.

Mexico: Les Etats-Unis Mexicains; Leur resources naturelle, Leur progres. Leur situation actuelle. Par R. de Zayas Enriquez, Ministere de Fomento, Rue San Andres, 15, City of Mexico.

Mexico: Memoria de la Secretaria de Fomento, 1892-1896. Ministere de Fomento, City of Mexico.

Michigan Farmers' Institutes, R. L. Butterfield, Director, Reports for 1896-1899.

Minneapolis Department of Health: Annual Reports, 1898-1899; A. K. Norton, M. D., Commissioner.

Missouri Botanical Garden, St. Louis; Wm. Trelease, Director: Annual Report, 1900.

Missouri Horticultural Society; L. A. Goodman, Secretary, Westport: 42nd Annual Report for 1899.

National Live Stock Association, Chas. F. Martin, Secretary, Denver, Colo.: Third Annual Report, 1900.

New Jersey State Board of Health, Henry Mitchell, M. D., Secretary, Trenton: 23rd Annual Report.

New South Wales Botanic Gardens, Sydney; J. H. Maiden, Director: Annual Report for 1898.

New York Botanical Garden, Dr. N. L. Britton, Director-in-Chief: Bulletin Vol. I, Part 4.

New York Farmers, the: Proceedings, 1899-1900; Mr. Thomas Sturgis, Secretary, 72 Trinity Place, N. Y. City.

New York State College of Forestry, Cornell University, Ithaca, N. Y.: First and second annual reports; B. R. Fernow, Director.

North Carolina Department of Agriculture, Biological Division: Regulations for the control of the contagious diseases of live stock.

North-West Brand Book, 1900: Registered cattle brands; Department of Agriculture, North-West Territories, Hon. Geo. H. Bulyea, Commissioner, Regina, Assiniboia, N. W. T.

Oberlin College Laboratory Bulletins of the Wilson Ornithological Chapter of the Agassiz Association, Lynds Jones, Editor, Oberlin, Ohio.

Ohio Archæological and Historical Society, Wm. C. Mills, Secretary, Columbus: "Publications," Vols. I to VII, inclusive, and Quarterly bulletins.

Ohio State Academy of Science, E. L. Moseley, Secretary, Sandusky: Eighth Annual Report, 1900.

Ohio State Board of Agriculture, W. W. Miller, Secretary, Columbus: Annual Report for 1898 and official reports on analysis of fertilizers.

Ontario Agricultural College, Guelph, Ont., Can.: Reports of college and experimental farm.

Ontario Department of Agriculture, Hon. John Dryden, Minister of Agriculture: Annual Report for 1898. 2 Vols.

Pennsylvania Department of Agriculture, Prof. John Hamilton, Secretary, Harrisburg: Annual Report for 1898 and bulletins.

Philadelphia Commercial Museum, Wm. P. Wilson, Director: Bulletins.

Society for the Promotion of Agricultural Science, Prof. Thomas F Hunt, Secretary, Columbus: Proceedings of the 20th annual meeting.

Station Viticole et de Pathologie Végétale, Fondée et dirigée par V. Vermorel, Villefranche (Rhone) France; Note sur l'emploi du sulfure de carbone en grande culture: Etude sur le grêlet: Defense des recoltes par le tir du canon.

Switzerland: Station laitiere de Lausanne, G. Martinet, Directeur: Extraits de la Chronique agricole du Canton de Vaud.

Trinidad: Annual Report Royal Botanic Gardens, 1898; J. H. Hart, Superintendent.

Tuskegee Normal and Industrial Institute, Tuskegee, Ala.: Bulletins of experiment station; G. W. Carver, Director.

United States Department of Agriculture, Hon. James Wilson, Secretary: Year-book for 1899, and many publications of divisions. The station is under special obligations to the chiefs of the various Divisions in this department and to Prof. Cleveland Abbe, editor of the U. S. Monthly Weather Review, for courteous assistance in completing the files of the various departmental publications.

University College of North Wales, Bangor; Thomas Winter, M. A., Professor of Agriculture: Ninth annual report on experiments with crops and live stock for 1899.

University of Minnesota: Minnesota Plant Life, by Conway MacMillan, State Botanist.

University of Pennsylvania: Contributions from the Botanical laboratory.

University of the State of New York; Melvil Dewey, Secretary, Albany: Reports of State Geologist, 1895, 1896; of State Entomologist, 1897; of State Botanist, 1897; of Director of State Museum, 1897 and State Library Bulletins on legislation, Nos. 11 and 12 ("Index to Legislation by States, 1899" and "Trend of Legislation in the United States").

Victoria Department of Agriculture: Experiments on rust in wheat and on fodder plants, by D. McAlpine, Government Vegetable Pathologist, Melbourne, Victoria, Australia.

Virginia Department of Agriculture, George W. Koiner, Commissioner: Official bulletin on analysis of fertilizers, 1899.

Wien: Verhandlung du K. K. Zoologisch-botanischen Gesellschaft in Wien; Redigiert von Dr. Carl Fetsch, 1899.

Wisconsin Farmers' Institutes, Geo. McKerrow, Director: Reports 1896-1899.

GOVERNMENT SERIAL PUBLICATIONS.

Agricultural Gazette of New South Wales: Issued monthly by direction of the Secretary for Mines and Agriculture, Sidney, New South Wales, Australia.

Agricultural Journal, Cape of Good Hope: Published monthly by the Department of Agriculture, Cape Town, South Africa.

Agricultural Journal and Mining Record: Issued fortnightly by the Natal Department of Agriculture and Mines, Maritzburg, Natal, South Africa.

Boletin de Agricultura, Mineria e Industrias: Publicado por la Secretaria di Fomento, Colonizacion e Industria de la Republica Mexicana: Published monthly, City of Mexico.

Boletin de la Sociedad Nacional de Agricultura: (Published monthly at 772 Monjitas, Chile, South America.)

Boletin Mensual de Observatorio Meteorologico Central de Mexico: Oficina Tipografica de la Secretaria de Fomento, City of Mexico.

Consular Reports: Published monthly by the U. S. Department of State, Washington, D. C.

Experiment Station Record: Published monthly by Office of Experiment Stations, U. S. Department of Agriculture, Washington, D. C.

Journal of Agriculture and Industry of South Australia: Issued monthly under direction of the Hon. Ministers of Agriculture and Industry, Adelaide, South Australia.

Queensland Agricultural Journal: Issued by direction of the Secretary of Agriculture, Brisbane, Queensland, Australia.

U. S. Monthly Weather Review: Prepared under the direction of the Chief of the U. S. Weather Bureau, Washington, D. C.

AGRICULTURAL AND TRADE JOURNALS.

Acker und Gartenbau Zeitung, Milwaukee, Wis.
Agricultural Epitomist, Indianapolis, Ind.
Agricultural Student, Columbus, Ohio.
American Agriculturist, New York City.
American Farmer, Indianapolis, Ind.
American Grange Bulletin, Cincinnati, Ohio.
American Guernsey Cattle Club Herd Register, Petersboro, N. H.
American Sheep Breeder and Woolgrower, Chicago, Ill.
Beet Sugar Gazette, Chicago, Ill.
Boletin de Agricultura Tropical. San Jose de Costa Rica, A. C.
Breeder and Farmer, Zanesville, Ohio.
Breeders' Gazette, Chicago, Ill.
California Cultivator, Los Angeles, Cal.
Canadian Entomologist, London, Ontario, Canada.
Chicago Daily Drovers' Journal, Chicago, Ill.
Cincinnati Price Current, Cincinnati, Ohio.
Daily Drovers' Telegram, Kansas City, Mo.

Dairy and Creamery, Chicago, Ill.
Deutsch-Amerikanischer Farmer, Lincoln, Chicago and New York.
Deutsche Landwirtschaftliche Wochenschrift, Berlin, Germany.
Dorset Quarterly, Washington, Pa.
Elgin Dairy Report, Elgin, Ill.
Fanciers' Review and Fruit Grower, Chatham, N. Y.
Farm and Fireside, Springfield, Ohio.
Farm Home, The, Springfield, Ill.
Farmers' Advocate, London and Winnipeg, Canada.
Farmers' Guide, Huntington, Ind.
Farmers' Home, Dayton, Ohio.
Farmers' Institute Bulletin, Fayetteville, N. Y.
Farmers' Magazine, Madison, Wis.
Farmers' Review, Chicago, Ill.
Farmers' Tribune, Des Moines, Iowa.
Farmers' Voice, Chicago, Ill.
Farm, Field and Fireside, Chicago, Ill.
Farm Journal, Philadelphia, Pa.
Farm Magazine, The, Milwaukee, Wis.
Farm, Stock and Home, Minneapolis, Minn.
Forester, The, Princeton, N. J.
Fruit Growers' Journal, Cobden, Ill.
Gleanings in Bee Culture, Medina, Ohio.
Golden Egg, The, St. Louis, Mo.
Green's Fruit Grower, Rochester, N. Y.
Hoard's Dairyman, Fort Atkinson, Wis.
Holstein Friesian Register, Brattleboro, Vt.
Homestead, The, Des, Moines, Iowa.
Hospodar (Bohemian), Omaha, Neb.
Indiana Farmer, Indianapolis, Ind.
Insect World (Japanese), Gifu, Japan.
Japanese Agriculturist (Japanese), Azabu, Tokio, Japan.
Jersey Bulletin, Indianapolis, Ind.
Journal of Agriculture, St. Louis, Mo.
Market Basket, Philadelphia, Pa.
Michigan Sugar Beet, Bay City, Mich.
Mirror and Farmer, Manchester, N. H.
Montana Fruit Grower, Missoula, Mont.
National Farmer and Stock Grower, National Stock Yards, Chicago, Ill.
National Fruit Grower, St. Joseph, Mich.
National Provisioner, New York, N. Y.
National Stockman and Farmer, Pittsburg, Pa.
Naturaliste Canadien, Le, Chicorstimi, Quebec, Can.
North American Horticulturalist, Monroe, Mich.
Ohio Farmer, Cleveland, Ohio.
Oregon Agriculturist, Portland, Oregon.
Popular Agriculturist (Japanese), Tokyo, Japan.
Practical Dairyman, Chatham, N. Y.
Practical Farmer, Phildelphia, Pa.
Prairie Farmer, Chicago, Ill.
Southern Planter, Richmond, Va.
Southwest, The, Springfield, Mo.
Southern Farm Magazine, Baltimore, Md.
Southwestern Farmer, Wichita, Kan.

Statistical Sugar Trade Journal: Willett & Gray, 91 Wall St., N. Y. City.
Strawberry Specialist, Kittrell, N. C.
Sugar Beet, Philadelphia, Pa.
Tri-State Farmer and Gardner, Chattanooga, Tenn.
Wallace's Farmer, Des Moines, Iowa.
West Virginia Farm Reporter, Charleston, W. Va.
Western Creamery, San Francisco, Cal.
Western Fruit Grower, St. Joseph, Mo.
Western Tobacco Journal, Cincinnati, Ohio.

GENERAL NEWSPAPERS.

From Ohio.

Crawford County News, Bucyrus.
Cumberland Echo, Cumberland.
De Graff Journal, De Graff.
Democrat, Pomeroy.
Democratic Herald, Delaware.
Fremont Journal, Fremont.
Geneva Free Press, Geneva.
Greenville Democrat, Greenville.
Hardin County Republican, Kenton.
Jacksonian, Wooster.
Medina County Gazette, Medina.
Monroe Journal (German), Woodsfield.
New Waterford Magnet, New Waterford.
News Democrat, Georgetown.
Ohio State Journal, Columbus.
Press-Review, Payne.
St. Paris Era-Dispatch, St. Paris.
Semi-Weekly Gazette, Delaware.
Shelby Times, Shelby.
Tipp Herald, Tippecanoe City.
Tri-State Farm News, Toledo.
Tuscarawas Chronicle, Uhrichsville and Dennison.
Utica News-Herald, Utica.
Wayne County Herald, Wooster.
Weekly Gazette, Cincinnati.

From other States.

Baltimore Weekly Sun, Baltimore, Md.
Detroit Free Press, (Semi-weekly), Detroit, Mich.
Kansas Semi-Weekly Capital, Topeka, Kan.
Orilla Packet, Orilla, Ontario, Canada.
Public Ledger (Daily), Philadelphia, Pa.
Rural Topics, Morgan City, La.
Salt Lake Herald (Semi-weekly), Salt Lake City, Utah.
Weekly Union, Manchester, N. H.
Weekly World-Herald, Omaha, Neb.

The Station is also under obligations for the following favors:

SEEDS, PLANTS AND SUNDRIES.

Adler Color and Chemical Works, New York City, Nos. 2, 3, 4, 5, 6, Arseneids.

Albright, B. F., Coalburg, O.: 1 Variety of potato.

American Cereal Co., Chicago, Ill.: 4 tons of "Quaker Dairy Feed."

Barnes Mfg Co., Mansfield, O.: 1 spray pump.

Barteldes, F. & Co., Lawrence, Kan.: 2 pkts. seeds.

Bowker Chemical Co., Boston, Mass.: 10 lbs. Arsenlead; 10 lbs. Disparene.

Boyd, F. O. & Co., N. Y. City: 50 lbs. sugar beet seed.

Brown & Son, Kansas City, Mo.: Diseased gladiolus corms.

Bucher & Gibbs Plow Works, Canton, O.: 25 lbs. sugar beet seed.

Burpee, W. A. & Co., Philadelphia, Pa.: 28 pkts. seeds.

Calhoun, J. W., Savannah, O.: 8 varieties seedling potatoes.

Cox, U. F., Bradrick, O.: 1 variety apple cions.

Crawford, M., Cuyahoga Falls, O.: 1 variety of strawberry plants.

Dirk, John V., Wingston, O.: 1 gallon seed corn.

Earhart, W. H., Lexington, O.: 1 variety of apple cions.

Farnsworth, W. W., Waterville, O.: 3 varieties apple cions.

Flansburgh & Pierson, Leslie, Mich.: 1 variety of strawberry plants.

Funk, Levi, Waynesburg, Pa.: 1 variety raspberry.

Gill, Geo. W., Columbus, O.: 2 bushels seed wheat.

Graves, W. J., Perry, O.: 1 variety of peach trees.

Grey, F. L., Amelia, O.: 1 variety raspberry plants.

Hanover, H. D., Dayton, O.: Clematis plants for study of disease.

Haymaker, A. O., Earlville, O.: 1 variety raspberry plants.

Heath, F. C., Tidal, Pa.: 5 varieties of potatoes.

Holaday, A., Scappoose, Oregon: 1 variety cherry tree.

Holmes, Harry L., Harrisburg, Pa.: Several pkts. seeds.

Hunt, R. A., Euclid, O.: One dozen pear trees for study of disease.

Lebold, F. A., Bolivar, O.: 1 variety of potato.

Lentz, D. J., Piqua, O.: 1 variety of potato.

Mace, G. W., Greenville, O.: 1 variety of potato.

Martin, H. H., Mapleton, O.: 2 varieties of strawberry plants.

Miller, D. J., Saltillo, O.: Apple, plum and cherry cions; 1 variety raspberry plants.

Moore, S. R., Zanesville, O.: 2 varieties apple cions.

Myers, Dr. John A., 12–16 John St., N. Y. City: 4 bags nitrate of soda.

Nichols, A. M., Granville, O.: 1 variety tomato seeds.

Owen, W. H., Catawba Island, O.: Samples whale oil soaps.

Persing, M. J., Clyde, O.: Apple cions and currant plants.

Pioneer Nursery Co., Salt Lake City, Utah: 1 variety pear cions.

Poole & Bailey, N. Y. City: Insecticide soaps.

Richie, Atlantic, Iowa: 1 variety raspberry plants.

Root, A. I., Medina, O.: 1 variety potato.

Sampsel, S. A., Clyde, O.: 1 variety strawberry plant.

Scott, Geo. E., Mt. Pleasant, O.: 1 peck seed corn.

Stearns, Elmer, Los Angeles, Cal.: Seeds of *Pinus Parryana* Nutt.

Sterling, C. C., Grand Rapids, O.: 1 variety peach tree.

Stoothoff, H. A. & Co., N. Y. City: Tobacco and whale oil soaps.

Todd, W. S., Greenwood, Del.: 1 variety strawberry plant.

Troyer, A. J., Hector, O.: 1 peck seed oats.

U. S. Department of Agriculture: Section of pure seed investigation; 5 centuries of American economic seeds; sugar beet seeds; sorghum seeds and seeds of cereals.

Van Orman, Lewis, Iowa: 4 pkts. seeds.

Waddell, A. L., Tumwater, Wash: 1 variety apple cions.

Wallis, Henry, Willston, Mo.: 1 variety grape vines.

Warstler, Geo. T., Justus, O.: 1 variety potato.

West Disinfectant Co., Chicago, Ill.: 1 gallon disinfectant.

Whiton, W. W., Wakeman, O.: 1 variety of potato.

Willow Branch Nursery, Anderson, O.: 1 variety strawberry plants.

Wohlert, A. E., Alton, Pa.: 1 variety of cauliflower.

Respectfully submitted,

CHAS. E. THORNE, *Director*.

APPENDIX A.

The Orchard and Nursery Inspection Law.

An act to prevent the introduction and spread of the San Jose scale and other dangerous insects and dangerously contagious diseases affecting trees, shrubs, vines, plants and fruits.

SECTION 1. *Be it enacted by the General Assembly of the State of Ohio*, That the Board of Control of the Ohio Agricultural Experiment Station immediately on the taking effect of this act, shall appoint a competent person or persons who shall, under the direction of the Board, perform the duties hereinafter provided.

SECTION 2. It shall be the duty of the Board, either in person or through their assistants, to seek out and cause to be exterminated the San Jose scale and other dangerous insects, and tree, shrub, vine, or plant diseases. Black knot and Peach yellows are hereby declared to be dangerous within the meaning of this act, and trees, shrubs, vines or plants affected with either of these diseases, shall be subject to its provisions. The mention of San Jose scale, peach yellows and black knot in this section shall not be held to exclude other insects or diseases which may be found to be dangerous, from the provisions of this act.

Said Board in person, or through their assistants, shall examine once in each year, not later than August 15th, all nuresries in the State of Ohio as to whether they are infested with San Jose scale or other dangerous insects, or infected with dangerously contagious tree, vine, shrub, or plant disease; and if upon inspection, such nurseries appear to be free from such insects or diseases, the Board shall upon the receipt of $10.00 give each owner of such nursery or nurseries, a certificate to the facts, provided that it shall require but one day or part of one day to make such inspection,. and for each additional day or fraction thereof required to complete the inspection, $5.00 shall be charged therefor, and collected before the certificate is granted. In addition to the above fee nurserymen must furnish transportation to and from railway station, and facilities for reaching their growing stock, to such person or assistants selected by the Board to make said inspection. This certificate shall be void after August 15th, of the year following. A duplicate of each certificate, together with a statement of amount received therefor, shall be filed by said person or assistants with the Secretary of the Board, within ten days of its issue, and neglect to file such duplicate of certificate and statement shall be treated as a misdemeanor. If any dangerously injurious insects or infectious diseases are found on the premises of any nursery, or nusery stock, the Board may order and enforce such treatment of said nursery stock, as they may deem sufficient in addition to a thorough inspection before granting a certificate, and the same per diem shall be charged for overseeing treatment as for nursery inspection. Whenever a nurseryman or any other person shall ship or deliver within this state, except for scientific purposes, trees, shrubs, plants or other nursery stock, he shall place upon each car load, box, bale or package a copy of a certificate, the original of which is signed by a state or government inspector, stating that stock has been inspected and has been found apparently free from dangerous insects and dangerously contagious tree, shrub, vine and plant diseases. The illegal use of said certificate

by changing, defacing or placing it on uninspected stock, or using the same after date of expiration or revocation, shall render the owner or shipper liable to the penalty prescribed for a violation of this act.

No person growing for sale any trees, shrubs, vines, or plants, shall deliver the same without applying to the Board for the certificate provided for in this act.

Provided, however, that existing certificates, issued by the Entomologist of the Ohio Agricultural Experiment Station, shall be held to be valid until June 1, 1900.

SECTION 3. It shall further be the duty of said Board through their assistants to cause the examination of all orchards, gardens, and other premises, either public or private, which they shall have reason to suppose to be infested or infected with any dangerously injurious insects or infectious diseases, liable to spread or to be conveyed to other premises, and for this purpose, said Board and their assistants are authorized, during reasonable business hours, to enter into or upon any farm, orchard, nursery, garden, storehouse or other building or place used for growing, storing, packing or sale of nursery and other horticultural products. If said Board or their assistants shall find on inspection as aforesaid that any nursery, orchard, garden, or other property or place is infested or infected with such dangerously injurious or infectious diseases liable to spread or to be conveyed to other premises, to the serious injury of the property thereon, the same shall be declared a public nuisance, and they shall notify, in writing, the owner or persons in charge of such infested or infected property, and shall direct him, within a time and in a manner prescribed in such notice, to use such measures as shall prevent the conveyance or spread of such insects or disease to the property of others and such infested or infected property must not be removed from the premises after the owner or person in charge of the same shall have been notified as aforesaid, without the written permission of said Board or their assistants. If the person so notified shall refuse or neglect to treat and disinfect said premises or property in the manner and within the time prescribed, it shall be the duty of the Board to cause such premises or property to be so treated, and they shall certify to the owner or person in charge of such premises one-half of the cost of the treatment. If said sum is not paid to them within sixty days thereafter, the same may be recovered, together with the costs of action, before any court in the state having competent jurisdiction. Any tree, plant, shrub, etc., which may in the judgment of the Board or their assistants, be so badly infested, or infected, as to render expense of treatment unjustifiable, shall be declared a public nuisance and may be destroyed by them or their assistants without liability for compensation to the owner thereof. Right of appeal from the decision or requirements of the assistants may be made to the said board, within three days after notice of such decision or requirements has been served, and the decision of the Board shall be final.

SECTION 4. Every package of trees, shrubs, vines or plants shipped into this state, from any other state, territory, country or province, shall be plainly labeled on the outside with the name of the consignor, and consignee, and a certificate showing that the contents have been inspected by a state or government officer, and that the trees, shrubs, vines or plants therein contained appear to be free from all dangerous insects and dangerously infectious diseases. If any trees, shrubs, vines, or plants are shipped into this state without such certificate plainly fixed on the outside of the package, box or car containing the same, the facts must be reported within twenty-four hours to the said Board by the railroad, express or steamboat company, or by other person or persons carrying the same, and it shall be unlawful to deliver any such property until it has been examined by the Board or their assistants and by them certified to be apparently free from dangerous insects or dangerously contagious diseases. Any

agent or any common carrier, or persons carrying such property as aforesaid, who shall fail to give such notice as hereby required shall be deemed guilty of a violation of this act. When nursery stock is shipped into this state accompanied by a certificate as herein provided, it shall be held prima facie evidence of the facts therein stated. But the Board by themselves or their assistants, when they have reason to believe that any such stock is infested or infected as heretofore described shall be authorized to inspect the same. In case such stock is found to be infested or infected by any of the aforesaid insects or plant diseases, such stock shall be held subject to order of shipper not to exceed ten days before being declared a public nuisance and destroyed. All expenses incurred by the Board or their assistants, in carrying out the provisions of this act shall be paid out of the funds appropriated by this act.

SECTION 5. Any person violating or neglecting to carry out the provisions of this act, or offering any hindrance to the carrying out of this act shall be adjudged guilty of a misdemeanor, and upon conviction before any justice of the peace, shall be fined not less than ten dollars and not more than one hundred dollars for each and every offense, together with all the costs of prosecution, and shall stand committed until the same is paid. It shall be the duty of the County Prosecuting attorney to prosecute all violations of this act and all amounts so recovered shall be paid over to the State Treasury.

SECTION 6. The Board shall make an annual report to the Governor of the State, a copy of which shall be sent to the Ohio State Horticultural Society at its annual meetings, showing the number of nurseries inspected, the number of certificates issued, the number of trees treated or disinfected by them or their assistants, the kinds and amount of property destroyed by them in pursuance of this act and such other facts concerning the operation of their office, under this act, as the said Board may deem necessary.

SECTION 7. The provisions of this act shall not apply to florist's green house plants, bulbs, flowers and cuttings, commonly known as green house stock.

SECTION 8. The said assistants shall pay over to said Board of Control, all funds coming into their hands under the provisions of Section 2, of this act, with an itemized statement of the sources whence received, which moneys shall be used by said Board to aid in carrying into effect the provisions of this act, and the amount so received shall be stated in the annual report of said Board. The said assistants shall also make to said Board an itemized statement of their expenses and the amounts paid for assistants employed in prosecuting the work under this act, which, when certified by the said Board, shall be paid out of the State Treasury upon the warrant of the Auditor of State.

SECTION 9. There is hereby appropriated to the said Board of Control for the purpose of carrying out the provisions of this act the sum of ($15,000.00) fifteen thousand dollars for the years of 1900 and 1901, or so much thereof as may be necessary. The Auditor of State is hereby authorized to draw his warrants upon the State Treasurer against the sum herein appropriated upon the presentation of proper vouchers and the State Treasurer shall pay the same out of any funds in the public treasury, not otherwise appropriated.

SECTION 10. An act known as "House Bill 508" ["House Bill 580"], passed October 18, 1896 ["April 18, 1896"], entitled "Ohio Black-knot Yellows and San Jose Scale Law" is hereby repealed.

SECTION 11. Whereas an emergency exists, therefore this act shall take effect and be in force on and after its passage.

(Signed) A. G. REYNOLDS,
Speaker of the House of Representatives,

JNO. A. CALDWELL,
President of the Senate.

Passed April 14, 1900.

APPENDIX B.

BULLETINS

OF THE

Ohio Agricultural Experiment Station.

1899-1900.

CONTENTS.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 120. JUNE, 1900.

METEOROLOGICAL SUMMARY—PRESS BULLETINS—INDEX.

METEOROLOGICAL SUMMARY FOR 1899.

BY C. A. PATTON.

EXPLANATION OF TABLES.

The following tables contain statistics of temperature, rainfall, etc., for the year, and are compiled from data obtained by daily observations. T stands for "trace"—less than .01 inch of rainfall. Temperature is given in degrees Fahrenheit.

Table I shows the daily rainfall at the Station during the year in inches and hundredths.

Table II shows the daily mean temperature for each day of 1899, the monthly mean temperature with the twelve years' average.

Table III gives a comparison of the monthly mean temperature and rainfall for the Station, with the twelve years' average for the same.

Table IV gives a comparison of the monthly mean temperature and rainfall for the State, with the twelve years' average for the same.

Table V gives the monthly mean temperature and rainfall for the Station and State for 1899 with the twelve years' average for the same.

Table VI contains the mean temperature, the highest and lowest temperatures, with the range of temperatures for each month; the number of clear, fair, and cloudy days; the rainfall and prevailing direction of wind, for the Experiment Station 1899.

Table VII contains the principal points of interest on temperature, state of weather and rainfall for the Station during the year and a grand summary for twelve years.

Table VIII contains the principal points of interest on temperature, state of weather and rainfall for the State during the year and a grand summary for seventeen years.

The statistics for the State and for this Station previous to 1893 are compiled from the publications of the Ohio Meteorological Bureau and State Weather Service, the twelve-year average being computed from the observations of the Wooster Station of the Ohio Meteorological bureau, now located on the grounds of the Experiment Station, one mile south of Wooster.

NOTES ON THE WEATHER AT THE STATION, 1899—SUMMARY BY MONTHS.

JANUARY.

The mean temperature for January was 26.6°, which is .4° below the Station average for January. The highest temperature, 55°, occurred on 4th, 14th and 23rd. The lowest, —6°, on the 31st. Cloudy weather prevailed, rain or snow fell on ten days. The total precipitation was 3.29 inches, which is .04 inch below the Station average for January. The prevailing wind was south..

FEBRUARY.

The mean temperature for February was 21.3°, which is 6.6° below the Station average for February. The highest temperature, 57°, occurred on the 26th, the lowest, —21°, on the 10th. Cloudy weather prevailed, rain or snow fell on nine days. The total precipitation was 1.64 inches, which is 1.53 inches below the Station average for February. The prevailing wind was south and southwest.

MARCH.

The mean temperature for March was 35°, which is .6° below Station average for March. The highest temperature, 67°, occurred on the 11th, the lowest, 9°, on the 8th. Cloudy weather prevailed, rain or snow fell on seventeen days. The total precipitation was 3.95 inches, which is .62 inch above the Station average for March. The prevailing wind was northwest.

APRIL.

The mean temperature for April was 52.1°, which is 3.2° above the Station average for April. The highest temperature, 86°, occurred on the 30th, the lowest, 21°, on the 2nd and 5th. Clear weather prevailed, rain or snow fell on seven days. The total precipitation was 1.28 inches, which is 1.22 inches below the Station average for April. The prevailing wind was southeast.

MAY.

The mean temperature for May was 60°, which is 2.4° above the Station average for May. The highest temperature, 86°, occurred on

the 16th, the lowest, 30°, on the 21st. Fair weather prevailed, rain fell on eleven days, the total rainfall was 4.42 inches, which is .07 inch above the Station average for May. The prevailing wind was south.

JUNE.

The mean temperature for June was 69.4°, which is 1.4° above the Station average for June. The highest temperature, 92°, occurred on the 6th, the lowest, 40°, on the 17th. Clear weather prevailed, rain fell on eleven days. The total rainfall was 1.95 inches which is 2.07 inches below the Station average for June. The prevailing wind was north.

JULY.

The mean temperature for July was 70°, which is .7° below the Station average for July. The highest temperature, 94°, occurred on the 24th, the lowest, 45°, on the 10th. Fair weather prevailed, rain fell on eleven days. The total rainfall was 3.73 inches, which is .38 inch below the Station average for July. The prevailing wind was south.

AUGUST.

The mean temperature for August was 71°, which is 2.3° above the Station average for August. The highest temperature, 95°, occurred on the 20th, the lowest, 39°, on the 7th. Clear weather prevailed, rain fell on three days. The total rainfall was 0.53 inches, which is 2.13 inches below the Station average for August. The prevailing wind was southeast.

SEPTEMBER.

The mean temperature for September was 61.6°, which is 1.5° below the Station average for September. The highest, 94°, occurred on the 3rd, the lowest, 32°, on the 30th. Fair weather prevailed, rain fell on thirteen days. The total rainfall was 5.56 inches, which is 2.38 inches above the Station average for September. The prevailing wind was northwest.

OCTOBER.

The mean temperature for October was 55°, which is 5.3° above the Station average for October. The highest temperature, 92°, occurred on the 24th, the lowest, 22°, on the 30th. Clear weather prevailed, rain or snow fell on eight days. The total precipitation was 2.21 inches, which is .34 inch below the average for November. The prevailing wind was south.

NOVEMBER.

The mean temperature for November was 43.2°, which is 3.4° above the Station average for November. The highest temperature, 66°, occurred on the 18th, the lowest, 22°, on the 27th. Fair weather prevailed, rain or snow fell on seven days. The total precipitation was 1.59

inches, which is 1.85 inches below the Station average for November. The prevailing wind was southwest.

DECEMBER.

The mean temperature for December was 29°, which is 2.8° below the Station average for December. The highest temperature, 63°, occurred on the 12th, the lowest, —2°, on the 16th. Cloudy weather prevailed, rain or snow fell on nine days. The total precipitation was 2.78 inches, which is .04 inch above the Station average for December. The prevailing wind was west.

METEOROLOGY — TABLE I.— RAINFALL.

DAILY RAINFALL AND MELTED SNOW FOR 1899 AT EXPERIMENT STATION.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	......	......	......	T	.09	.25	......	......	.74	......	T	T
2	......	......	.18	T	......	T	......	......	......	......	......	T
3	......	.35	T	......	......	......	......	......	.08	......	.56	.35
4	.80	T	.60	......	.39	......	.03	.13	......	......	.06	.11
5	.10	.30	.10	......	.03	T	......	.35	.05	......	......	T
6	.40	.05	T	......	......	T	.03	......	.22	......	......	......
7	......	.05	.20	.50	.03	.59	.38	......	1.25	......	......	......
8	......	......	......	.05	T	.41	.52	......	.60	.04	......	......
9	.10	......	......	.05	......	.04	......	......	......	.07	......	......
10	......	......	.05	......	......	......	......	......	......	......	.02	.03
11	......	T	.04	......	.09	......	......	......	.04	.06	.07	.47
12	T	......	.06	.32	.03	......	T	......	......	......	......	.25
13	.22	......	T	......	.03	......	.40	......	......	......	......	......
14	1.43	......	......	......	......	.02	.08	......	......	......	.62	.80
15	......	......	.02	......	T	.15	.69	......	......	......	.04	......
16	......	T	......	.04	T	......	.35	......	......	......	......	......
17	......	T	......	......	1.40	......	.02	......	......	.60	......	......
18	.05	......	.43	T	T	......	......	......	.17	.04	......	T
19	......	......	.23	.12	......	T	T	......	.96	T	......	.57
20	......	......	.06	......	......	.24	......	......	T	.01	......	......
21	......	.35	.07	......	......	......	......	T	......	......	T	......
22	......	.14	.28	......	......	......	T	......	T	......	T	......
23	......	T	.63	......	......	......	......	......	T	......	.24	.10
24	.05	......	T	T	......	.04	T	......	.01	......	......	.08
25	.02	......	.40	.20	......	.06	1.05	......	1.00	......	......	T
26	.10	.30	......	......	......	......	T	.05	.27	......	......	......
27	......	.09	......	......	1.17	......	......	......	......	T	......	......
28	......	.01	.55	......	T	.12	T	......	T	1.03	......	......
29	......	......	T	......	.83	.03	.18	......	.17	.36	......	.02
30	......	......	.05	......	......	......	......	......	......	......	T	T
31	......	......	T	......	.33	......	......	......	......	T	......	......
Totals	3.29	1.64	3.95	1.28	4.42	1.95	3.78	.53	5.56	2.21	1.59	2.78
Averages	.11	.06	.13	.04	.14	.07	.12	.02	.19	.07	.05	.09

METEOROLOGY — TABLE II.— TEMPERATURE.

MEAN TEMPERATURE FOR EACH DAY OF 1899 AT THE STATION.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	14.0	3.5	30.0	28.0	73.5	71.5	65.5	69.0	79.0	38.5	52.0	47.0
2	18.0	25.0	37.0	27.0	69.0	66.5	76.0	77.5	72.0	35.5	45.5	38.0
3	32.0	25.0	46.0	29.0	64.0	64.5	77.5	72.0	75.0	50.5	39.5	39.0
4	45.5	26.0	43.0	30.5	60.5	74.0	79.5	78.5	62.0	56.0	41.0	28.0
5	37.5	18.5	35.0	33.5	57.0	80.0	75.0	72.5	71.0	57.0	37.5	21.0
6	24.0	12.5	25.0	40.0	57.5	79.0	71.0	70.5	67.0	50.5	42.5	25.0
7	15.0	10.5	18.0	44.5	60.0	77.0	60.0	55.0	70.5	48.5	37.0	27.5
8	22.5	2.5	19.0	35.5	56.5	71.5	57.5	63.5	59.0	48.5	42.5	37.5
9	30.5	—8.0	31.5	36.0	58.0	66.5	65.0	65.0	63.5	57.0	43.0	33.5
10	19.0	—10.0	40.5	41.5	60.0	62.5	68.5	78.5	57.5	60.0	51.0	47.5
11	11.0	—8.0	51.0	51.0	61.5	61.5	73.0	79.0	63.5	61.0	47.0	54.5
12	25.5	4.5	48.0	61.0	60.5	73.5	74.0	77.0	65.0	67.5	39.0	50.0
13	36.5	6.0	31.0	59.0	64.0	73.0	69.5	62.0	56.5	65.0	37.0	37.5
14	45.5	5.0	37.0	61.5	54.5	76.5	71.5	65.0	52.5	67.5	45.0	31.0
15	38.0	21.5	46.0	46.5	56.0	74.0	69.0	63.5	54.5	68.0	49.0	23.0
16	40.5	27.0	33.5	41.0	63.5	61.0	75.0	65.0	64.5	65.0	48.0	12.0
17	37.0	37.5	32.5	51.5	65.0	57.5	69.5	67.0	73.0	65.5	46.5	24.0
18	23.5	35.5	49.0	60.0	55.0	61.5	66.0	69.0	71.0	61.0	56.0	36.5
19	20.5	31.0	38.5	61.5	48.0	71.0	67.5	74.0	61.0	52.0	50.5	41.5
20	26.5	40.5	25.5	59.5	47.0	75.0	72.0	76.0	56.5	50.0	42.5	33.0
21	36.5	42.0	30.5	64.5	44.5	66.5	73.5	80.5	58.0	40.5	42.0	36.5
22	35.0	41.0	44.5	65.5	45.0	71.5	74.5	71.5	62.0	50.5	51.5	31.5
23	46.0	29.5	40.0	66.0	51.5	79.0	74.5	68.0	60.5	58.5	42.5	32.5
24	38.5	25.0	27.5	68.0	56.5	73.0	75.5	70.0	66.5	66.0	32.5	27.0
25	26.0	30.5	32.0	63.5	59.0	70.5	75.5	75.5	61.0	58.0	39.0	18.5
26	31.0	47.0	34.5	62.0	65.0	65.5	73.5	72.0	53.0	58.5	37.0	12.0
27	15.5	38.5	36.5	65.0	70.0	62.5	48.5	72.5	46.5	57.5	34.5	16.0
28	18.5	36.5	34.0	70.5	72.5	71.5	71.0	71.0	56.5	56.5	37.5	15.5
29	9.0	......	26.5	70.0	69.0	64.5	76.0	71.0	52.0	47.0	41.5	11.5
30	10.5	......	31.5	75.0	67.0	61.5	67.5	72.5	43.5	40.5	46.5	4.5
31	1.0	......	31.5	......	70.0	......	64.5	78.0	......	46.0	......	7.5
Monthly mean	26.6	21.3	35.9	52.1	60.0	69.4	70.0	71.0	61.6	55.0	43.2	29.0
Twelve-year average	27.0	27.9	35.6	48.9	57.6	68.0	70.7	68.7	63.1	49.7	39.8	31.8

METEOROLOGY — TABLE III.

MONTHLY MEAN TEMPERATURE AND RAINFALL FOR TWELVE YEARS AT WOOSTER.

Temperature in degrees Fahrenheit.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1888	*23.0	28.4	31.7	46.3	57.7	*68.9	70.1	67.8	57.1	44.9	40.7	31.4	47.3
1889	31.1	22.9	38.7	47.1	57.8	64.5	70.0	66.0	60.8	45.3	39.3	40.7	48.6
1890	36.0	36.6	30.9	48.4	56.0	69.8	70.5	65.8	59.6	50.0	41.3	28.8	49.5
1891	30.0	34.0	32.0	49.6	52.0	68.0	68.0	71.0	68.0	49.0	38.0	37.0	49.6
1892	22.0	33.0	33.0	47.0	57.0	70.0	70.0	69.0	61.0	49.0	38.0	23.0	48.0
1893	18.0	28.0	38.0	50.1	57.6	69.3	72.0	67.9	63.2	52.3	37.7	30.9	48.7
1894	32.8	26.7	43.5	50.5	57.5	67.9	71.4	69.2	66.1	52.3	36.5	32.9	50.6
1895	21.9	17.9	32.4	49.5	59.4	69.9	68.6	70.9	66.5	44.2	40.4	32.8	47.8
1896	27.9	29.2	29.8	54.6	64.5	65.6	70.2	68.5	60.6	45.8	44.4	30.6	49.3
1897	24.0	30.0	39.3	47.2	53.4	64.3	73.2	67.0	66.7	55.9	40.7	31.8	49.4
1898	31.6	27.4	43.3	45.3	58.2	68.7	74.5	71.1	66.2	52.6	38.4	27.9	50.4
1899	26.6	21.3	35.0	52.1	60.0	69.4	70.0	71.0	61.6	55.0	43.2	29.0	49.5
Averages	27.0	27.9	35.6	48.9	57.6	68.0	70.7	68.7	63.1	49.7	39.8	31.8	49.0

Rainfall — Inches.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1888	3.52	2.43	3.34	2.48	3.82	2.31	4.54	4.35	1.92	3.18	4.95	1.39	3.18
1889	4.38	2.42	2.13	1.58	2.97	4.86	6.73	1.98	4.05	1.36	3.53	3.93	3.32
1890	4.71	6.20	4.37	3.10	6.01	5.57	2.67	4.66	5.12	7.45	2.61	1.74	4.51
1891	2.74	4.83	3.71	1.66	2.24	7.13	3.28	1.85	0.94	1.33	5.73	2.92	3.20
1892	2.67	2.67	3.38	2.44	7.69	7.89	4.73	2.69	3.20	0.37	2.06	1.74	3.46
1893	4.01	6.33	1.89	5.66	6.28	2.51	1.38	1.53	1.85	5.18	2.49	1.50	3.38
1894	2.19	3.37	2.36	1.74	4.41	2.23	1.38	0.76	4.07	2.53	2.41	3.15	2.55
1895	3.92	1.00	1.98	1.69	1.38	4.20	2.19	2.30	3.92	1.15	4.21	3.51	2.62
1896	1.73	2.27	3.67	3.34	3.41	3.98	3.05	1.96	5.16	0.71	1.78	2.41	3.21
1897	2.82	2.64	2.81	2.75	4.97	2.98	3.89	3.86	0.29	0.89	5.76	2.50	3.01
1898	4.10	2.27	6.44	2.56	4.60	2.70	6.79	5.53	2.15	4.28	4.14	2.29	3.99
1899	3.29	1.64	3.95	1.28	4.42	1.95	3.73	6.53	5.56	2.21	1.59	2.78	2.74
Averages	3.33	3.17	3.33	2.50	4.35	4.02	4.11	2.66	3.18	2.55	3.44	2.49	3.26

* From Canton record.

METEOROLOGY—TABLE IV.

MONTHLY MEAN TEMPERATURE AND RAINFALL FOR TWELVE YEARS FOR THE STATE.

Temperature in degrees Fahrenheit.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1888	24.3	30.5	34.2	49.2	59.1	70.4	72.1	70.4	60.3	47.9	42.9	33.3	49.5
1889	33.3	25.8	40.2	49.9	60.2	66.7	72.5	69.1	62.9	47.9	41.0	43.8	51.1
1890	33.8	39.4	34.5	51.3	59.2	73.3	73.1	68.8	62.1	52.7	43.9	31.2	52.3
1891	33.0	36.0	35.0	52.0	58.0	71.0	69.0	70.0	67.0	51.0	40.0	39.0	51.7
1892	24.0	35.0	35.0	49.0	59.0	73.0	73.0	71.0	64.0	52.0	38.0	29.0	50.1
1893	18.0	29.0	38.0	50.2	58.3	70.6	74.5	70.7	65.2	53.7	39.3	32.7	51.6
1894	37.7	28.9	45.1	50.6	60.0	71.3	74.3	71.2	67.8	53.9	37.5	33.9	52.3
1895	28.4	19.6	35.5	51.7	61.1	72.0	71.6	73.5	69.0	46.9	41.3	33.9	49.9
1896	29.4	30.5	32.4	56.7	67.9	69.5	73.2	71.8	62.7	49.0	45.1	32.9	51.7
1897	25.5	32.4	41.5	49.3	46.8	68.1	75.5	69.4	66.9	58.1	42.2	32.8	50.6
1898	32.4	30.0	45.0	47.2	61.0	71.9	76.0	73.5	67.8	53.1	38.8	28.8	52.1
1899	27.8	21.6	36.9	53.3	63.3	71.5	74.1	73.7	64.1	57.4	43.9	30.2	51.5
Averages	28.9	29.9	37.8	50.8	59.4	70.7	73.2	71.1	65.0	51.9	41.1	33.4	51.2

Rainfall—Inches.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1888	3.65	1.74	3.55	1.39	3.77	3.41	4.40	5.16	2.27	3.98	4.25	1.47	3.30
1889	3.13	1.35	1.50	1.79	3.71	4.18	4.25	1.50	3.62	1.78	4.02	2.81	2.79
1890	4.94	5.25	5.29	3.15	5.52	4.50	1.99	4.70	5.56	4.27	2.53	2.37	4.17
1891	2.82	4.91	4.19	2.13	2.20	4.82	3.82	3.07	1.50	1.76	5.00	2.39	3.21
1892	2.05	3.27	2.16	2.63	4.63	6.73	3.18	6.15	1.27	0.67	2.62	1.85	3.09
1893	2.56	5.13	2.09	6.37	4.97	3.34	2.49	2.17	1.57	4.24	2.09	2.61	3.30
1894	2.14	2.79	2.16	2.31	4.00	2.65	1.56	1.67	3.81	2.01	2.17	2.98	2.47
1895	4.00	0.69	1.59	2.11	1.80	2.44	2.00	2.96	1.66	1.22	4.11	3.85	2.37
1896	1.67	2.25	3.34	2.78	2.67	4.81	3.11	3.38	5.13	1.20	2.63	1.65	3.29
1897	1.98	3.64	5.17	3.27	3.98	2.85	4.65	2.72	0.78	0.64	6.62	2.39	3.21
1898	5.25	2.32	6.23	2.38	4.10	2.86	3.98	4.50	2.56	3.72	3.17	2.71	3.65
1899	3.01	2.11	4.66	1.68	4.32	2.96	4.18	1.82	2.69	2.14	1.72	3.16	2.87
Averages	3.09	2.95	3.49	2.71	3.80	3.79	3.71	3.31	2.66	2.30	3.41	2.52	3.14

METEOROLOGY—TABLE V.

MEAN TEMPERATURE AND RAINFALL FOR THE STATION AND STATE, 1899, AND FOR TWELVE YEARS.

Temperature in degrees Fahrenheit. Rainfall in inches.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Mean temperature at the Station, 1899	26.6	21.3	35.0	52.1	60.0	69.4	70.0	71.0	61.6	55.0	43.2	29.0	49.5
Twelve years average temperature at the Station	27 0	27.9	35.6	48.9	57.6	68.0	70.7	68.7	63.1	49.7	39.8	31.8	49.0
Mean temperature for the State, 1899	27.8	21.6	36.9	53.3	63.3	71.5	74.1	73.7	64.1	57.4	43.9	30.2	51.5
Twelve years average temperature for the State	28.9	29.9	37.8	50.8	59.4	70.7	73.2	71.1	65.0	51.9	41.1	33.4	51.1
Rainfall at the Station, 1899	3.29	1.64	3.95	1.28	4.42	1.96	3.78	0.53	5.56	2.21	1.59	2.78	2.74
Twelve years average rainfall at the Station	3.33	3.17	3.33	2.50	4.35	4.02	4.11	2.66	3.18	2.55	3.44	2.49	3.26
Rainfall for the State, 1899	3.01	2.11	4.66	1.68	4.32	2.96	4.18	1.82	2.69	2.14	1.72	3.16	2.87
Twelve years average rainfall for the State	3.09	2.95	3.49	2.71	3.80	3.79	3.71	3.81	2.66	2.30	3.41	2.52	3.14

METEOROLOGY—TABLE VI.

SUMMARY BY MONTHS FOR 1899.

	Temperature.											Number of days.						
	Mean.	Highest.	Date.	Lowest.	Date.	Range.	Mean daily range.	Greatest daily range.	Date.	Least daily range.	Date.	Clear.	Fair.	Cloudy.	Rain fell, .01 or more.	Monthly rainfall.	Average daily rainfall.	Prevailing wind.
At the Station —																		
January	26.6	55	*1	—6	31	61	17.0	26	4	6	6	6	5	20	10	3.29	.11	S.
February	21.3	57	26	—21	10	78	16.1	27	*2	3	18	8	3	17	9	1.64	.06	S.-S. W.
March	35.0	67	11	9	8	58	20.3	33	21	3	31	3	8	20	17	3.95	.13	N. W.
April	52.1	86	30	21	*3	65	21.3	36	13	6	1	18	8	4	7	1.28	.04	S. E.
May	60.0	86	16	30	21	65	24.3	45	16	12	*4	10	17	4	11	4.42	.14	S.
June	69.4	92	6	40	17	52	24.3	39	27	11	9	16	12	2	11	1.96	.07	N.
July	70.0	94	24	45	10	49	25.5	39	1	6	15	12	15	4	11	3.73	.12	S.
August	71.0	95	20	39	7	56	28.9	46	17	11	5	20	10	1	3	0.53	.02	S. E.
September	61.6	94	3	32	30	62	25.8	43	7	7	20	8	11	11	13	5.56	.19	N. W.
October	55.0	92	24	22	30	70	26.3	52	24	10	*5	13	10	8	8	2.21	.07	S.
November	43.2	66	18	22	27	44	18.1	34	9	8	*6	7	12	11	7	1.59	.05	S. W.
December	29.0	63	12	—2	16	65	27.6	34	17	5	10	5	3	23	9	2.78	.09	W.
Sums and averages	49.5	79	......	19	......	60	22.9	38	......	8	......	126	114	125	116	2.74	.09	S.
For the State —																		
January	27.8	66	4	—15	31	81	......	46	27	......	......	......	......	......	9	3.01	......	S. W.
February	21.6	67	20	—39	10	106	......	52	15	......	......	......	......	......	9	2.11	......	S. W.
March	36.9	76	11	0	7	76	......	48	22	......	......	......	......	......	15	4.66	......	N. W.
April	53.3	94	*1	6	3	88	......	47	13	......	......	......	......	......	6	1.61	......	S. W.
May	63.3	96	3	28	22	68	......	......	......	......	......	......	......	......	12	4.32	......	S. W.
June	71.5	102	22	36	17	63	......	......	......	......	......	......	......	......	9	2.96	......	S. W.
July	74.1	105	4	41	10	64	......	......	......	......	......	......	......	......	......	4.18	......	S. W.
August	73.7	104	20	39	7	65	......	......	......	......	......	......	......	......	......	1.82	......	N. E.
September	64.1	107	5	26	30	81	......	......	......	......	......	......	......	......	8	2.69	......	N. W.
October	57.4	94	14	20	1	74	......	......	......	......	......	......	......	......	6	2.14	......	S. W.
November	43.9	79	11	18	*2	61	......	......	......	......	......	......	......	......	6	1.72	......	S. W.
December	30.2	69	11	—7	*3	76	......	......	......	......	......	......	......	......	12	3.16	......	S. W.
Sums and averages	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	....

*1 4th, 14th, 23rd. *2 1st, 27th, 28th. *3 2nd, 5th. *4 18th, 19th. *5 11th, 31st. *6 15th, 16th.

State *1 29, 30. *2 7, 27. *3 30, 31.

METEOROLOGY — TABLE VII.

SUMMARY BY YEARS AND GRAND SUMMARY FOR TWELVE YEARS AT WOOSTER.

	1888.	1889.	1890.	1891.	1892.	1893.	1894.
At......	Wooster.	Wooster.	Wooster.	Wooster.	Wooster.	Experiment Station.	Experiment Station.
Mean temperature	47.3°	48.6°	49.5°	49.6°	48.°	48.7°	50.6°
Highest temperature	....	91.5° *1	94.5° Aug. 3.	99.° Aug. 8.	98.° July 25.	95.° *5	98.° July 19.
Lowest temperature	—5° Feb. 9.	—5.° *2	1.° March 7.	0.° March 1.	—20.° Jan. 20.	—9.° Jan. 11.	—7.° Dec. 28.
Range of temperature	....	96.5°	98.5°	99.°	118.°	104.°	105.°
Mean daily range of temperature	....	18.7°	18.9°	21.°	19.°	20.2°	22.9°
Greatest daily range of temperature	....	42.° April 23.	41.° Jan. 13.	42.° Sept. 23.	46.° July 7.	45.° Aug. 9.	45.° July 31.
Least daily range of temperature	....	2.° Jan. 6.	4.5° *3	4.° Feb. 8.	4.° *4	3.° *6	4.° *7
Number of clear days	....	125	109	116	116	96	127
Number of fair days	....	108	119	110	123	164	154
Number of cloudy days	....	137	137	125	98	105	84
Number of days rain fell	....	119	149	119	119	129	130
Total rainfall	38.23 inches.	39.87 inches.	54.21 inches.	38.36 inches.	41.46 inches.	40.61 inches.	30.60 inches.
Greatest monthly rainfall	4.54 inches.	6.73 in.—July.	7.45 in.—Oct.	4.26 in.—June.	7.89 in.—June.	6.33 in.—Feb.	4.41 in.—May.
Least monthly rainfall	1.39 inches.	1.36 in.—Oct.	1.74 in.—Dec.	1.95 in.—April.	1.37 in.—Oct.	1.38 in.—July.	0.76 in.—Aug.
Prevailing direction of wind	S	S	S	S	S. W..........	S, W....	S. W..........

*1 July 10. Sept. 1. *2 Feb. 23 and 24. *3 Jan. 8 and Sept. 10. *4 March 5, Nov. 1, 3, 25, and Dec. 1, 18. *5 July 7, 28, and Sept. 7. *6 Jan. 24, Feb, 11, May 26. *7 Dec. 1, 28.

METEOROLOGY—TABLE VII—Concluded.

SUMMARY BY YEARS AND GRAND SUMMARY FOR TWELVE YEARS AT WOOSTER.

At	1895. Experiment Station.		1896. Experiment Station.		1897. Experiment Station.		1898. Experiment Station.		1899. Experiment Station.		Summary for twelve years.	
Mean temperature	47.8°		49.6°		49.4°		50.4°		49.5°		49.1°	
Highest temperature	98°	June 4.	93.°	Aug. 9.	96.°	*10	96.°	July 3.	95.°	Aug. 20.	99.°	Aug. 8, 1891.
Lowest temperature	—6.°	*8	—6.°	Feb. 19.	—18.°	Jan. 26.	- 9.°	Feb. 2.	—21.°	Feb. 10.	—21.°	Feb. 10, 1899.
Range of temperature	104.°		99.°		114.°		105.°		116.°		120.°	
Mean daily range of temperature	21.8°		19.°		21.5°		20.3°		22.9°		20.5°	
Greatest daily range of temperature	55.°	Oct. 6.	43.°	May 8.	49.°	Oct. 5.	50.°	Nov. 14.	52.°	Oct. 24.	55.°	Oct. 6, 1895.
Least daily range of temperature	1.°	Nov. 27.	3.°	*9	0.°	Feb. 6.	5.°	*11	3.°	Feb. 18.	0.°	Feb. 6, 1897.
Number of clear days	125		130		124		133		126		120	
Number of fair days	117		106		123		104		114		121	
Number of cloudy days	123		130		115		128		125		118	
Number of days rain fell	102		134		128		134		116		125	
Total rainfall	31.45 inches.		38.47 inches.		36.16 inches.		47.85 inches.		32.98 inches.		39.18 inches.	
Greatest monthly rainfall	4.21 in.	Nov.	8.05 in.	July.	5.76 in.	Nov.	6.79 in.	July.	5.56 in.	Sept.	8.05 in.	July, 1896.
Least monthly rainfall	1.00 in.	Feb.	0.71 in.	Oct.	0.29 in.	Sept.	2.15 in.	Sept.	0.58 in.	Aug.	0.29 in.	Sept., 1897.
Prevailing direction of wind	N.		S. W		N. W.		N.—S. W		S		S.	

*8 Jan. 12, 13 and Feb. 5. *9 Jan. 10, March 8. *10 July 5, 6. *11 Jan. 21, March 2, Dec. 18.

METEOROLOGY—TABLE VIII.

SUMMARY BY YEARS AND GRAND SUMMARY FOR SEVENTEEN YEARS FOR THE STATE.

For the State.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.
Mean temperature	49.4°	50.6°	48.°	49.6°	51.4°	49.5°	51.1°	52.4°	52.°
Highest temperature	98.° Aug. 22.	99.° { Sept. 28. Oct. 1.	101.° July 21.	98.6° July 7.	108.° July 18.	102.° Aug. 8.	99.5° Aug. 31.	103.1° Aug. 3	101.° Aug. 10.
Lowest temperature	-17.2° Jan. 22.	-34.° Jan. 25.	-31.° Jan. 29.	-21.5° Jan. 7.	-21.° Jan. 17.	-15.° Jan. 27.	-18.5° Feb. 24.	-4.° March 7.	-5.° March 5.
Range of temperature	115.5°	133.°	132.°	120.1°	129.°	117.°	113.°	107.1°	106.°
Greatest daily range of temperature	55.2° Mar. 18.	50.° { Sept. 5. Dec. 4.	58.5 Jan. 30.	57.° Dec. 11.	57.° April 11.	50.°	53.° Mar. 30.	49.5° Apr. 11.	50.° { April 27–30.
Average number of days rain fell	146	145	148	131	121	125	115	149	120
Mean yearly rainfall	44.98 inches.	40.19 inches.	30.08 inches.	37.71 inches.	33.60 inches.	39.64 inches.	33.53 inches.	50.83 inches.	38.61 inches.
Mean daily rainfall	.123 inch.	.110 inch.	.104 inch.	.001 inch.	.092 inch.	.108 inch.	.092 inch.	.138 inch.	.110 inch.
Prevailing wind	S. W.	S. W.	S. W.	S. W.	S. W.	S. W.	S. W	S. W.	S. W

	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	Summary for seventeen years.
Mean temperature	50.°	50.1°	52.4°	49.9°	51.8°	50.6°	52 °	51.5°	50.7°
Highest temperature	103.° July 25.	102.° June 19.	105.° { July 18–19.	106.° July 20.	103.° Apr. 17.	113.° July 4.	105.° July 1.	105.° Sept. 6.	113.° { July 4 1897.
Lowest temperature	-25.° Jan. 20.	-24.°	-27.° Dec. 29.	-24.° Feb. 6.	-18.° *2	-27.° Jan. 26.	-20.° Feb. 3.	-39.° Feb. 10.	-39.° { Feb. 10, '99.
Range of temperature	128.°	126.°	132.°	130.°	121.°	140.°	125.°	144.°	152.°
Greatest daily range of temperature	51.° Sept. 25.	54.6°	60.° Oct. 19.	59.° *1	53.° Mar. 25.	67.° Sep. 25–26	....	....	....
Average number of days rain fell	121	113	100	89	124	110	121	107	120
Mean yearly rainfall	37.16 inches.	39.63 inches.	29.75 inches.	28.46 inches.	39.58 inches.	38.54 inches.	43.78 inches.	34.51 inches.	37.88 inches.
Mean daily rainfall	.100 inch.	.110 inch.	.080 inch.	.070 inch.	.120 inch.	.100 inch.	.119 inch.	.094 inch.	.104 inch.
Prevailing wind	S. W.	S. W.	S. W.	S. W.	S. W.	S. W.	S. W.	S. W.	S W.

*1 Jan. 15, Mar. 29. *2 Feb. 9, 10, 11.

PRESS BULLETINS.

Eighteen press bulletins have been published during the year, several of which have been later incorporated in the general series. Those not thus incórporated are republished here.

No. 194, August 7, 1899: NITROGEN AND POTASH IN FERTILIZER. (Incorporated in Bulletin 110.)

No. 195, August 15, 1899: STOMACH WORMS IN SHEEP. (Incorporated in Bulletin 117.)

No. 196, August 14, 1899: COMPARISON OF VARIETIES OF WHEAT. (Incorporated in Bulletin 118.)

No. 197, August 21, 1899: STOMACH WORMS IN SHEEP. SUCCESSFUL TREATMENT.

The letters which are being received almost daily at the Ohio Experiment Station, complaining of the ravages of the sheep stomach worm, indicate that this parasite is unusually abundant this season, and it is believed that the following experience of Mr. J. E. Wing in the use of the Julien benzine treatment, described in Press Bulletin 195 of this Station, may be of very great value to sheep owners.

The treatment, it will be observed, is extremely simple and inexpensive, and farmers whose lambs are unthrifty or dying are urged to follow Mr. Wing's plan of determining, by post mortem examination, either of a lamb which died or of one which has been killed for the purpose, whether the trouble is due to this parasite.

The parasite is to be looked for in the fourth stomach, and is a minute, white, thread-like worm, about three-fourths of an inch in length.

REPORT OF MR. WING.

About August first ('98) a car-load of lambs was received here from the Chicago market. They were not all from one grower but evidently had come from several sources, some being range lambs, others farm grown. Some were grade Shropshires, others were white-faced and of doubtful origin, favoring the Mexican type. The lambs were thin and some beginning to scour. Soon after reaching here they became worse and the scouring and emaciation progressed rapidly. About 45 died before my attention was called to the sheep.

At once I diagnosed them as being affected with stomach worms, (*Strongylus contortus*), and as soon as another died we made a post mortem examination which proved the correctness of the diagnosis, for the worms were present in the fourth stomach in thousands. It was simply a writhing mass of worms, some even twined together in balls as large as marbles. The lamb was apparently free from other parasites.

The treatment began immediately, gasoline being administered to the entire lot, whether seeming sick or well. It took about one minute to dose each lamb, three men working. The dose given was two teaspoonfuls of common gasoline with four ounces of sweet milk, well shaken together to form an emulsion. Each dose was mixed separately.

Of the 240 lambs treated one died, apparently from the effect of the medicine. Most of them seemed to mind it very little and soon began to eat.

They were treated three times at intervals of 24 hours; each time being given two teaspoonfuls of gasoline in four ounces of milk. After the first dose they seemed to improve, the scouring checked and the movements became more lively and the eyes brighter.

After four days we selected two of the worst cases for killing and made careful post-mortem examination of them. Before killing it was noted that the dung had become quite natural in color and consistency. The skin was also becoming slightly pinkish in hue, although time enough had not elapsed to allow complete recovery from the anæmic condition that accompanies worm infection.

The first lamb killed was very thin and had less than the normal amount of blood, but that seemed of nearly normal quality. Examination of the lungs showed a small area of congestion, accounting for the cough that had been somewhat noticeable before treatment. This lung affection seems to usually accompany infection from stomach worm. There can be no direct connection, but doubtless the weakening of the system invites invasion of other disease germs. No trace of the verminous parasites of the lungs was found, so that it is believed that the affection was more in the nature of congestion from a light attack of pneumonia or kindred disorder. The liver was normal, possibly larger in proportion than the other organs. The kidneys were small, one almost wasted away, but no disease was apparent, the atrophy seeming more in the nature of a dwindling because of the general lowness of the health of the animal.

The intestines were healthy, no nodular disease apparent, no tape-worms present. In the colon were found a few worms that at first were believed not to be stomach worms; they were slightly thicker than natural specimens and white in color, but further examination under the microscope seemed to decide that they were really *Strongylus contortus*, quite out of place and perhaps not destined to live very long.

Above this place no worms of any sort were found. The fourth stomach in particular was entirely free from them and while not quite in a normal condition, yet seemed nearly so.

I wish to emphasize the fact that not one stomach worm was found in the usual lodging place of the pest; that the few found in the colon were many feet away from their natural living place and not apparently in good health, and that it is probable that they were driven there by the fumes of the gasoline and would eventually have passed out and perished.

The digestion of this lamb had so improved and its organs were in such comparatively good condition that there is no reason to suppose that it would not have become fat, although it is hardly probable that it would have reached the development that might have been expected had this invasion not been suffered.

The second lamb dissected revealed a similar condition, except that the kidneys were normal and the lungs nearly so; no stomach worms were found in any part, but a very few nodules were seen on the intestines. It is improbable that there were enough of them to have interfered much with its fattening. This lamb had also resumed a normal condition in regard to the contents of the intestines and was evidently gaining fast.

The testimony of the men who care for the lambs is that since having the gasoline they seem like a different lot of sheep entirely. They eat hungrily, are lively in their movements, do not scour, and have all the appearance of beginning to thrive.

Excepting the one that died none have been injured in the least by the treatment, so far as can be observed.

The dissection was performed by Dr. E. R. Stockwell, a skillful veterinarian.

JOSEPH E. WING.

Mechanicsburg, O.

No. 198, August 21, 1899: VARIETIES OF WHEAT AND HOME-MIXED FERTILIZERS.

(1) A SEVEN-YEAR COMPARISON OF VARIETIES OF WHEAT. (Incorporated in Bulletin 118.)

(2) A COMPARISON OF FACTORY-MIXED AND HOME-MIXED FERTILIZERS.

For three years the Ohio Experiment Station has been carrying on a field test in which four different brands of factory-mixed fertilizers have been compared with mixtures of slaughterhouse tankage, acid phosphate and muriate of potash, made up by the Station so as to carry as nearly as possible the same percentage of nitrogen, phosphoric acid and potash as those claimed for the factory mixtures. The plan of this test is to grow corn, wheat and clover in rotation, the fertilizers being applied to the corn and wheat. The land is divided into three sections, in order that each crop may be grown each year. In starting the test in 1897 two sections were planted to corn, thus duplicating the test that year. One of these was sown to wheat in the fall and one to Soy beans in the spring, so that the crops of 1898 were wheat, corn and Soy beans. Clover was sown on the wheat in 1898 and has been harvested this year. The wheat sown for this year's crop, however, was destroyed by winter-killing, and was plowed up and sown to oats. The crops thus far harvested, therefore, have been three of corn and one each of wheat, oats, Soy bean hay and clover hay. Following are the average results obtained:

		Average yield per acre.	
		From 4 factory brands.	From 4 home mixtures.
Corn, 3 crops	bush.,	43.94	34.33
Wheat, 1 crop	bush.,	9.94	12.55
Oats, 1 crop	bush.,	36.52	36.17
Soy beans, 1 crop	lbs.,	5,450	5,690
Clover hay, 1 crop	lbs.,	1,620	1,955

It will be seen that the spring crops show but little difference from the two kinds of fertilizers, but the wheat and clover show a marked preference for the home mixture.

Apparently the chemical treatment, by which it is claimed that the nitrogen of the factory fertilizers is made more available, results in making it so readily soluble that it is washed out of the soil before the wheat and clover can make use of it.

No. 199, September 11, 1899: PLUMS — A COMPARISON OF VARIETIES. (Incorporated in Bulletin 113.)

No. 200, November 6, 1899: FALL TREATMENT OF INSECT PESTS.

(1) FALL TREATMENT OF WHEAT FIELDS WHERE CROP HAS BEEN DESTROYED BY HESSIAN FLY.

Reports are coming to the Ohio Agricultural Experiment Station, complaining of serious ravages of the Hessian fly in wheat fields. In many cases, it is being claimed, that among the early sown fields hardly a plant has escaped attack. The question is frequently asked whether it will pay to resow at this late date. In all cases where the first sowing has been destroyed by the fly, the ground should be replowed before sowing. In fact, it may be said that if fields have been ravaged past all possibility of securing a profitable crop next year, such fields should be plowed this fall, or very early next spring, preferably the former. It is probably too late, now, to risk resowing this fall, but it must be understood that, if left above ground, the fly will develop in these fields next spring and go to other fields to work its ravages.

As to how seriously a field must be infested to warrant plowing under this fall, that is a matter that each farmer must settle for himself. If the soil is rich and the weather during fall and spring very favorable for plant growth, the grain will yet send up a second growth of tillers this fall, which, if they withstand the winter, with a very favorable spring will supply enough straw to produce a part of a crop. But the risk is great, and no one, not on the ground, can safely advise in the matter.

Late sown wheat is escaping, very largely, the fall attacks of the fly, but the close proximity to a seriously injured field will endanger even a late sown field to attack next spring, unless the early sown field is plowed under before the adult flies appear.

(2) FALL MEASURES FOR PREVENTION OF CHINCH BUG ATTACK.

In western and southern Ohio, chinch bugs winter largely among matted grass, fallen leaves and other rubbish. They also winter over in great numbers in shocks of corn fodder, left out in fields over winter, and outbreaks in wheat fields, even where sown among corn, have again and again been traced to such shocks standing out over winter among the wheat. Shocks of corn, or fodder, should be drawn in from off the wheat fields this fall. When possible to do so, all matted grass, fallen leaves, or other rubbish bordering on wheat fields, should be burned between this date and May 1st next.

In the timothy meadows of northern and northeastern Ohio, where the timothy grass has this year been destroyed, examination should be made about the roots of the grass along the margins of such areas of destruction. If chinch bugs are found, they can be prevented from doing further injury, next spring by plowing the ground quite deeply this fall, which will place them so far below the surface that they will be destroyed, and thus prevented from continuing their ravages next year. In timothy meadows the pest must be looked for just below the surface of the ground about the bulbous roots of the grass.

(3) FALL AND WINTER WORK AGAINST INJURIOUS INSECTS.

Many of our most destructive insects pass the winter either among matted prostrate grass, among fallen leaves or especially along osage hedges, lanes and fence corners. Wherever such places can be burned over in late fall, winter or early spring, the effect will be to destroy many of these. Instead of having our annual clearing up in May, as many do who clear up their premises at all, this should be done during the seasons above mentioned, as by May many of the destructive insects have left their winter quarters and are beyond reach.

In the orchard, the falling of the leaves will reveal cocoons and even insects themselves upon the trees that can not be easily detected while the foliage is still hanging to these trees. Many insects pass the winter within a folded leaf that is attached to the twig to prevent it from dropping off, and in this way deceive the eye of the orchardist. It will pay to go over the orchard and remove all of the cocoons and dried leaves still clinging to the trees.

No. 201, November 13, 1899: FALL PLOWING VS. WHITE GRUBS AND WIRE WORMS.

(1) FALL MEASURES FOR PREVENTION OF THE RAVAGES OF THE WHITE GRUB ANOTHER YEAR.

What is commonly known as the white grub, or grub worm, is the young of the brown May beetle, or June bug, which occurs in such abundance in late May and June, and is not, as is often suggested, the young of the common Tumble bug. These May beetles deposit their eggs in June, usually about the roots of the grass. These eggs hatch in about a month, and the young grubs, though very

small, even immediately after hatching appear to be larger than the egg. They feed upon the roots of grass and by the first of November are about half an inch in length, having all the appearance of the full grown grub excepting in the matter of size. With the coming of cold weather, or perhaps more properly speaking, in late autumn, they go deeper into the ground, sometimes a foot or even more, and make for themselves small earthen cells by packing the earth more densely about their bodies, and in these cells pass the winter, coming upward in the spring, feeding upon the grass roots throughout the entire summer, and at the end of the second autumn they have reached about two-thirds of their ultimate dimensions. They now burrow into the ground, and again pass the winter in an earthen cell, coming to the surface again in the spring and feeding until the latter part of May, in this latitude, when they abandon the grass roots, burrow down into the ground, and again make an earthen cell within which they transform to the adult beetle.

It is possible that an occasional individual may appear above ground in the fall, but the mass of them pass the winter in this condition and come to the surface as adults the following May. Thus it will be seen that they have fed during a portion of three years. The young of the insect is, by nature, a grass feeder, and therefore, they are always more abundant in fields that have remained in grass for a long series of years. The major portion of their injury in cultivated fields occurs the first summer immediately following a series of grass crops.

From what has been stated of the life history of these pests the reason for this will be readily understood. Now, the insect cannot be kept off grass lands, nor is there any practical way of reaching these grubs under ground, and as they never get to the surface, their control by topical application is not only difficult but practically impossible. As yet, we have found but one practical way of dealing with these pests, and, while that is not infallible, it seems to prove effective in the majority of cases. This consists in the fall plowing of grass lands as a preparation for the grain crop the following year. While early fall plowing is known to be often effective, it is quite probable that late fall or winter plowing is much more dependable. The reason for this is that after the grubs have constructed their winter quarters they are probably too stupid to construct others. If then the ground is broken, the grubs within their winter quarters are either thrown up to the action of continued freezing and thawing, or, if not thrown up, are exposed to the more direct effects of rain and frost, and thus killed by the winter weather. That this method is effective in the majority of cases there can be hardly a doubt. During the present year the Ohio Agricultural Experiment Station has been in receipt of a number of letters stating that where portion of a field which, for some years, had been devoted to meadow or pasture, was plowed in the fall, and the remainder in the spring, the fall plowed portion escaped injury during the past summer, while the spring plowed portion suffered very severely.

A concensus of all the evidence obtained up to date, indicates that fall plowing is the most reliable and profitable method, known at present, for preventing the ravages of the white grub.

(2) FALL TREATMENT OF GRASS LANDS TO PREVENT THE RAVAGES OF WIRE WORMS.

The parent of the wire worm is an entirely different insect from that of the white grub. In this case, the fully developed insect being the slender, brownish beetles, known as snapping beetles on account of their habit, when placed upon their backs, of throwing themselves into the air with a slight snap and turning over and alighting upon their feet. Their life history is very much the same as that of the white grub. These are also grass feeding insects, but while the white grub is more usually found upon higher lands, which the female seems

to select for a place to deposit her eggs, the snapping beetles, or skip-jacks, seem to prefer the lower, cooler and damper lands. It is for this reason that the lower lands are more often affected by this pest, and it frequently occurs that the patches of black soil among clay will be more especially subject to infestation. While it would seem that the harder and more compact body of the wire worm would be less susceptible to climatic influences, nevertheless, we find no more practical prevention of the occurrence of this pest than the fall plowing of sod lands, and, as with the white grub, it is quite probable that late fall or winter plowing will be preferable. While this does not, in all cases, insure absolute freedom from the attacks of these insects, there seems a stronger probability of their ravages another year being prevented in this way than by any other known to us.

No. 202, November 27, 1899: OHIO SUGAR BEET WORK FOR 1899 AND 1900. (Incorporated in Bulletin 115.)

No. 203, February 26, 1900: FREE DISTRIBUTION OF IMPROVED VARIETIES OF SORGHUM.

The United States Department of Agriculture has, for a number of years, been conducting experiments in the improvement of varieties of sorghum. The result of this work is a considerable increase in the sucrose content of several varieties, which the Department is now offering for free distribution to the farmers of the country through the medium of the State Agricultural Experiment Stations. The Ohio Station, at Wooster, will receive a consignment of this seed, which will be distributed free to farmers within the state who wish to improve the quality of their sorghum cane.

Since the quantity of seed is limited and since the object of distribution is to furnish the farmers with a start of better varieties of sorghum, the seed will only be sent out in quantities sufficient to plant one acre or less.

Farmers in Ohio who wish to secure some of this seed should apply at once to

OHIO AGRICULTURAL EXPERIMENT STATION,
Wooster, Ohio.

No. 204, March 26, 1900: FREE DISTRIBUTION OF SORGHUM SEED.

More than four thousand requests for sorghum seed have been received by the Ohio Experiment Station, in response to its announcement of free distribution of improved seed, furnished by the National Department of Agriculture for this purpose. This large demand was altogether unexpected, as a similar announcement made a year ago, brought only 122 applications for seed. Since the supply of seed furnished by the Government, though very liberal, is altogether inadequate to furnish a sufficient quantity of seed to each of so many applicants for a satisfactory test, the Experiment Station has purchased a large additional quantity of seed from the same person in Kansas who furnishes the Government supply, and this will be added to the free distribution.

This is done from a desire not to disappoint those who are expecting seed from the Station and in belief that this seed, which has been carefully bred for ten years past, under the direct supervision of the Chemical Division of the National Department of Agriculture, will be the means of effecting a direct improvement in the sorghum crop of Ohio.

Even with this additional quantity of seed it will be impossible to send more than half a pound of seed to each applicant, but this will be sufficient for a fair test of the new varieties and will enable the farmers of the state to raise sufficient seed for next season's planting.

The seed will be sent out in April, in ample time for planting, as sorghum should not be planted in this latitude before the last of April or first of May. It grows so extremely slowly at first, especially in cool weather, that it will require extra labor to keep the weeds down if it is planted before the ground is reasonably warm.

A bulletin is in course of preparation which will give full directions concerning the culture and management of sorghum, which will be sent to all who receive seed and to such others as may apply for it.

No. 205, April 2, 1900: COMPARISON OF VARIETIES OF POTATOES.

The following varieties of potatoes comprise a partial list of those on trial at the Ohio Experiment Station the past season, the majority having been planted three seasons or more.

Those are included concerning which there is most interest at present, either because they are new or have been brought prominently before the public in various ways. Those are more especially noted which are worthy of commendation.

It is not the practice of the Station to say much about a variety until it has been tested more than one year, nor is it thought best to avoid mentioning a variety simply because it is not new.

The safest varieties for general planting are those which have been found to be adapted to a diversity of soils. To aid in the determination of varieties of this class is the object of these brief notes.

ACME.— An early variety, resembling the Early Ohio but rather more prolific, its average for three seasons being about ten per cent. above the Early Ohio. It ripens at about the same time as the Early Ohio.

BOVEE.—An early white variety with pink markings. It stands second in the list of early sorts as to productiveness. It is commonly ranked with the Early Ohio as to earliness, but it should be rated as a few days later. Its average yield for three years is about forty per cent. above the Early Ohio.

CARMAN NO. 3.—A well known second early, or late, white variety, similar in habit of growth and shape of tubers to the Rural New Yorker No. 2, but rather more prolific. The tubers are smooth and uniform in size, and nearly all are marketable. It is regarded as one of the best of its class for market, but as only second rate in quality.

CRAIGHEAD.—Tubers rather long, slightly flattened, smooth, white. A new midseason variety of considerable merit which has been on trial here three seasons. It has given good yields and the tubers are nearly all of marketable size.

COMMERCIAL.—A new midseason, pink variety, of considerable promise. The tubers are of good size, regular in shape and smooth. It has been on trial here two seasons and has given satisfactory yields.

EARLY TRUMBULL.—An early white variety of recent introduction. It stands at the head of the list in productiveness of early varieties on trial here for the past three years, giving an average of 271 bushels per acre. It has been given a trial in various localities, and while it is not alike successful in all localities, it appears to have given general satisfaction. Its season of ripening is with the Early Rose and Early Harvest. Heretofore Bovee and Early Harvest have stood at the head of early varieties in our trials, but the Early Trumbull must now be accorded first place.

EARLY MICHIGAN.—Another early white sort which has made a good record quite generally. Its average yield is a little below that of Early Harvest.

ENORMOUS.—A very prolific, late white variety. It is one of the heaviest yielding varieties thus far tested at the Station, its average for three years being 297 bushels per acre, or about 19 per cent. above the combined average of Car-

man No. 3, Sir Walter Raleigh and Uncle Sam, and 33 per cent. above Carman No. 3. It is, however, not quite as smooth as Sir Walter Raleigh and Carman No. 3, but not rough enough to impair its market value.

Green Bay Triumph.—A white skinned variety of the same shape as Bliss Triumph, and ripening at the same time. It has been tested here one season only, but gave a higher yield than any others of its class. It is a clearer white than the White Bliss Triumph and is worthy of commendation.

Livingston.—A white variety with pink eyes. It has given uniformly good yields here, and is generally satisfactory.

Pingree.—An early white variety with occasional markings. It has been on trial here two seasons only. It has given satisfactory yields, but does not keep as well as most other early varieties.

Uncle Sam.—A late white variety which has uniformly given good yields here. It is one of the best for late spring use that has been tried here. It gives about the same yields as Carman No. 3 but is not as smooth.

White Mountain.—A late white variety which has been on trial here two seasons, and has given good yields, standing near the head of the list in this respect.

Whiton's White Mammoth.—Another late white sort, of unusual merit. One year's experience with it indicates that it is a good cropper. The tubers are smooth, uniform in size and nearly all marketable.

No. 206, April 16, 1900: The Soy Bean a Substitute for Clover.

The Soy or Soja bean is an upright, stiff-stemmed, branching bean, introduced a few years ago from Japan, which is rapidly coming to the front as a most valuable forage plant. It has been grown for several years by the Ohio Experiment Station with very satisfactory results. Planted on some of our poorest soils, it has produced two to three tons of excellent dry forage or hay per acre, which is eaten with relish by all kinds of stock. As a crop to turn under for green manuring we do not know its equal.

As the Soy bean is a warm weather plant it should not be planted before the last of May in northern Ohio, nor before the middle in the southern part of the state. When planted for forage it is sown at the rate of a bushel and a half to the acre, on well prepared land, sowing with the wheat drill with all the runs open. Thus sown it soon covers the ground and there is no trouble from weeds or foxtail. It should be harvested before frost, and cured as hay.

The Soy bean, like clover, adds nitrogen to the soil, and it is therefore a renovating, instead of an exhausting crop. It is especially suited to take the place of clover in a systematic rotation where the clover has been killed out by severe winters, as is the case at present over a large part of Ohio, or where the spring seeding of clover has failed to catch. The Ohio Experiment Station has used it in such cases with such good results that it feels justified in urging the farmers of the state to give it a careful trial.

There are several varieties of Soy beans, some of which will mature seed in Ohio, while others will not. As a rule, the latter class are more valuable for forage, as they make larger growth. The beans, however, which are produced at the rate of ten to twenty bushels per acre, are a valuable feeding stuff, as they are quite high in protein, and to some extent take the place of such materials as linseed meal in the ration. The Kansas Experiment Station has fed them to fattening hogs with the result of effecting a large saving in the quantity of food required to make a pound of pork, and others report similar results in feeding them to sheep.

The Experiment Station has no seed of these beans for distribution, but it may be procured of most of the principal seedsmen.

No. 207, April 9, 1900: (1) Spring Treatment of Fields Where Wheat Has Been Destroyed by the Hessian Fly.

Nearly all over Ohio are thousands of fields of wheat that were badly damaged last fall by fly, which damage has been further emphasized by climatic effects of the winter, to such an extent that the devoting of these fields to other crops, the coming season, will be inevitable. Numerous questions have come to the Experiment Station as to how best to manage these fields.

The question has been asked if the fly will attack the young seeding; if it will attack oats; if it will lie in the ground till next fall and affect the wheat; or, if it is advisable to simply harrow oats upon these fields, seed with timothy, or disk and sow with oats. Before doing anything the farmer must understand, first, that within a few weeks these fields will be swarming with Hessian flies. We have been securing proof of this during the entire winter, by getting infested plants from various parts of the state and hatching out the flies in the warm temperature of the Insectary. When these flies come out from their winter condition, known as the "flax-seed,"—and, by the way, these mav be scattered all over the ground away from the plants — not finding sufficient wheat plants upon which to lay their eggs they will migrate to other fields. Thus a very seriously affected wheat field endangers, to a certain extent, every other field of wheat situated in the near vicinity. The only way to prevent this is to plow under the infested fields, turning the old wheat plants as deeply beneath the surface as possible, and harrowing and rolling the ground at once after plowing. This will prevent the flies from doing any further injury, for they will hardly be able to make their way through several inches of compact soil.

Second: Hessian flies will not attack grass, nor oats, but a simple harrowing or disking of the fields will really destroy but very few of them, leaving the rest to develop and go to other fields. Where the wheat has been killed out and the young seeding uninjured, it may look like an unprofitable piece of work to plow under such a field, and, in most cases, the farmer must decide which is the best course to pursue, but he must bear in mind that these flies will develop and go elsewhere to lay their eggs, and that they will not lay them upon oats or grass that may be growing in the same field. Then, again, it must be remembered that the wheat has yet to stand a second attack of the fly between this and harvest. There are probably many fields that look, this spring, as though they might produce a part of a crop, but by the time they have withstood the coming attack of the fly the prospects will be vastly diminished.

In summarizing, it may be said that all wheat fields that do not give fairly good promise of a crop, should be plowed under to a depth of from four to six inches, as quickly as possible, and the ground harrowed and rolled in order to prevent the flies from reaching the surface. The land may then be devoted to oats, corn or any other crop that may be practicable.

One object we have had in view in rearing flies throughout the winter, from plants secured in different portions of the state, was to determine the presence of natural enemies of the fly.

The most useful of these natural enemies winter over in the small, brown so-called "flax-seeds," in which the flies also pass the winter. If there were any large number of these present, it would not only prove that there were many less flies to be developed than there were young last fall, but that the effect of these on the next brood of the flies would be to destroy them and prevent injury; but, with all of our rearing, we have not succeeded in getting any of these natural enemies, though we have gotten myriads of flies, and these have deposited their eggs upon wheat plants in the Insectary. From all the information that we have been able to secure, in this way, there does not seem to be much help for the farmer, in this direction, between this and the time when the wheat is harvested.

THE ONION THRIPS.

The effect of this insect upon the onion is known as the "white blast," from the fact that the tops are prematurely whitened and become wrinkled and shriveled. The insect caused considerable damage in some portions of the state last year in onion fields, and the Ohio Agricultural Experiment Station has been engaged throughout the winter in studying its winter habits. It has been found that the insect passes the winter months in matted grass, among old weeds and other rubbish, as well as among cull onions and refuse that have been left over in the fields in the fall. Onion growers are familiar with the fact that the depredations of this insect appear earliest, and are the most emphasized, along the margins of fields or plots, or in spots over the fields. The reason for this is that the insect winters over in these places. It makes its way from the grassy margins or from the grassy banks of ditches, to the rows of onions adjoining. It winters over in the piles of culled onions and refuse in the fields, and begins its work there, spreading from thence outward. Wherever the grass and weeds along ditches can be rooted up and destroyed it prevents the harboring of this pest. Wherever the old, dry grasses and weeds, along the margins of onion plantations, can be burned, the effect will be to destroy myriads of the pest, and to prevent their breeding the coming season. With frequent, drenching rains, there is not much likelihood of a severe outbreak, but in case of drought, the insect is likely to work more or less serious injury in the extensive onion fields of Ohio.

A spray of one pound of whale oil soap dissolved in eight gallons of water will destroy the pest, and the use of this mixture is recommended on the first appearance of the insects in the fields. At time of first appearance it will probably only be necessary to treat very small areas along the margins of fields, or the small, isolated spots previously mentioned, in order to permanently check their increase.

No. 208, May 21, 1900: SAN JOSE SCALE, TREE AND PLANT DISEASES.

A law was enacted by the last General Assembly of Ohio "to prevent the introduction and spread of the San Jose scale and other dangerous insects and dangerously contagious diseases affecting trees, shrubs, vines, plants and fruits." The law provides for an annual inspection of every nursery in the state and forbids the transportation or sale within the state of uninspected nursery stock, whether grown within or outside of the state. It also provides for the inspection of orchards and the compulsory treatment of infected orchards, or the destruction of those in which the infection has progressed so far as to render treatment impracticable. Black knot and Peach yellows are declared to be dangerous within the meaning of the law. The execution of this law is lodged with the Board of Control of the Ohio Agricultural Experiment Station, and the Board has organized the work as a department of the Station, under the general control of the Director of the Station, as representative of the Board of Control, and under the immediate supervision of a chief assistant to be known as Horticultural Inspector. Mr. Lowell Roudebush, of Clermont county, a member of the State Horticultural Society, has been appointed to this position.

The object of this law is to prevent the spread of insects and plant diseases which threaten the destruction of our orchards, and the policy of the Board of Control will be to so carry out its provisions as to give the utmost possible assistance to the fruit growers and nurserymen of the State in the protection of their property. To this end the Inspector will visit suspected orchards on request, so far as his time will permit, and will give advice respecting their treatment. This will be done without any charge to the owner of the orchard except to convey the Inspector from the nearest railway station to the orchard and back again. Orchardists throughout the state are urged to avail themselves of this opporunity to ob-

tain expert advice, and to do so without any fear that valuable trees will be hastily condemned by the Inspector. On the contrary, no tree will be destroyed so long as there remains any reasonable chance of saving it, nor until its existence becomes a source of positive danger to trees adjoining. As the Inspector is himself a practical horticulturalist, the fruit growers of the state need have no fear but that this question will be treated from a business standpoint. It is the definite policy of the Board of Control to save and not destroy, a policy with which the Inspector is in full accord, and prompt action on the part of fruit growers in meeting the Board on this ground will save many an orchard that is doomed to destruction by these pests if longer neglected.

As nuserymen can no longer carry on their business in Ohio without a certificate from the Experiment Station they should make application for such certificate at once. Correspondence should be addressed to Experiment Station, Wooster, Ohio.

No. 209, May 28, 1900: THE CANKER WORM.

The so called "measuring worms" that are now stripping the leaves from apple and elm in many parts of Ohio are canker worms. Had they been taken in hand at their first appearance they might have been destroyed by spraying the trees with a mixture of from 4 to 6 ounces of Paris green with 4 to 6 pounds of slaked lime in 50 gallons of water, the lime being reduced to a milk of lime and strained through a fine wire seive, so as not to obstruct the nozzle of the spray pump; but when the canker worm has attained nearly its full growth it is not so easily killed and Paris green is not effective. At this stage, however, it may be destroyed by spraying with Swift's Arsenate of lead, Bowker's Arseniclead or Bowker's Disparene, using three pounds of the preparation to fifty gallons of water. These mixtures will not injure the foliage; when fully prepared they have a milky white appearance, and being nearly as thin as water they spray readily, and they adhere for several weeks, thereby avoiding the necessity for more than a single application. They may be obtained of Swift & Co., of Bowker Chemical Co., both of Boston, Mass. These are merely proprietary forms of the standard chemical compound, arsenate of lead.

Recent experiments carried out by the Entomological Department of the Ohio Agricultural Experiment Station have shown that within three days after application of these mixtures to trees seriously overrun by canker worms fully ninety per cent. of the worms were killed.

If treatment is neglected the worms will increase in numbers and by another season will probably kill the trees.

A complete, illustrated description of the canker worm, with its life history, is given in Bulletin 68 of the Ohio Experiment Station.

No. 210, June 4, 1900: SUGGESTIONS TO ORCHARDISTS FOR DESTROYING THE SAN JOSE SCALE.

Summer treatment of the San Jose scale should begin as early as the 15th of June and be continued until September 15th at least, with intervals of not more than ten days between sprayings. This will destroy a very large percentage of the young and thus prevent its spreading.

Two different mixtures can be used, viz.: I, whale oil soap, used at the rate of one-fourth pound to one gallon of water. This mixture will not injure the foliage of tree fruits.

II, a mechanical mixture of kerosene and water, in the proportion of one gallon of kerosene to ten of water, or what is called a ten per cent. solution. It can be used with safety on all tree fruits except the peach.

For winter treatment, which means while the leaves are off, a stronger solution of whale oil soap and water can be used—two pounds of the former to one gallon of the latter.

Kerosene from twenty to one hundred per cent. has been used with widely different results. The why has not been determined yet. Consensus of opinion is that it should be used on a sunshiny day—the higher the temperature the better.

KIND OF SPRAYER.

The whale oil soap solutions can be used with any of the better class of sprayers. The kerosene mixture requires a specially constructed one, with a device for the mechanical mixing of the kerosene and water, of which there are a number on the market.

In the destruction of trees, shrubs, vines, etc, infected with the San Jose scale, great care should be taken that stumps and sprouts are grubbed out thoroughly and burned with the trunk and branches—otherwise your work will be in vain and the infection but temporarily checked, not destroyed.

Bulletin 72, Ohio Agricultural Experiment Station, will give further information.

No. 211, June 11, 1900: BLACK-KNOT AND PEACH YELLOWS—HOW TO DESTROY THEM.

BLACK KNOT.

Black-knot is a fungous disease affecting the plum, cherry and kindred tree fruits. The Damson among plums, and the Morello class among cherries are the most susceptible.

SUMMER TREATMENT.

Beginning with the growing season the knots develop rapidly. They should be cut off as soon as seen and burned at once. The badly infected branches should be cut off below point of infection and burned, not left under the tree, nor piled in heaps and left in the orchard.

WINTER TREATMENT.

Affected trees that have been properly treated during the growing period will be free from knots, generally speaking. Should any remain after the leaves have fallen they should be cut off and burned, and badly affected branches also, not later than February 15th, as the spores or seeds are then ripe. A large majority of young trees can be saved by judicious prunning and will ultimately become healthy; otherwise the trees will die and infect others in your and your neighbor's orchard.

PEACH YELLOWS.

Yellows is a highly contagious, incurable disease of the peach. Trees affected with it should be destroyed at the earliest possible moment by uprooting and digging them out and burning roots, trunk and branches, including fruit, on site. No remedy save that has proven successful. Dragging diseased trees or branches through an orchard will infect healthy trees.

Late summer and fall are the most favorable times for detection of yellows by symptoms of fruit and twigs. These are: 1. Premature ripening of the fruit, which is highly colored and spotted and has the flesh marbled with red. 2. Premature unfolding of winter buds. 3. Abnormal development of new buds in the trunk and branches, which grow into slender, sickly-looking shoots.

Bulletins 72 and 92, Ohio Agricultural Experiment Station, will give fuller information, with illustrations.

INDEX.

PUBLICATIONS OF THE OHIO EXPERIMENT STATION.

The first six annual reports of this Station, for the years 1882 to 1887, inclusive, contain the full record of its work during that period. Such bulletins as were published during these years ("First Series") were intended for newspaper use; they were afterward incorporated in the annuals and no copies of the bulletins can now be furnished. The first and second annual reports are also out of print.

The "Second Series" of bulletins began with 1888. The first seven of these were included in the seventh annual report, and cannot be furnished separately. The bulletins published since 1888 are listed below.

No. 8 (Vol. II, No. 1, 1889) — Insects, insecticides and methods of collecting and studying insects. *Out of print.*

No. 9 (Vol. II, No. 2, 1889) — Colic of horses. *Out of print*

No. 10 (Vol. II, No. 3, 1889) — Silos and ensilage. Silage and field beets as food for cows. *Out of print.*

No. 11 (Vol. II, No. 4, 1889) — Experiments with small fruits. Effects of early and late picking upon keeping quality of apples. *Out of print.*

No. 12 (Vol. II, No. 5, 1889) — Wheat: Cultural and variety tests. *Out of print.*

No. 13 (Vol. II, No. 6, 1889) — Remedies for plum curculio and striped cucumber beetle. Notes upon strawberry root-louse, grain plant-louse and little known injurious insects. Prevention of potato rot. *Out of print.*

No. 14 (Vol. II, No. 7, 1889) — Cabbage and cauliflower, and treatment of certain plant diseases. *Out of print.*

No. 15 (Vol. II, No. 8, 1889 — Eighth annual report. Meteorological summary. Index.

No. 16 (Vol. III, No. 1, 1890) — Experiments with potatoes.

No. 17 (Vol. III, No. 2, 1890) — Field experiments with fertilizers.

No. 18 (Vol. III, No. 3, 1890) — Experiments with corn and oats. Actinomycosis.

No. 19 (Vol. III, No. 4, 1890) — Spraying to prevent insect injury. Insects affecting corn. Fungous diseases of plants. Collecting plants. *Out of print.*

No. 20 (Vol. III, No. 5, 1890) — Corn silage vs. sugar beets as food for milk production.

No. 21 (Vol. III, No. 6, 1890) — Wheat: Cultural and variety tests.

No. 22 (Vol. III, No. 7, 1890) — Strawberries and raspberries.

No. 23 (Vol. III, No. 8, 1890) — The plum curculio, cucumber bettle, rhubarb curculio and clover stem borer. Potato blight.

No. 24 (Vol. III, No. 9, 1890) — Asparagus. Transplanting onions.

No. 25 (Vol. III, No. 10, 1890) — Grape rot and corn smut.

No. 26 (Vol. III, No. 11, 1890) — Ninth annual report. Meteorological summary. Index.

No. 27 (Vol. IV, No. 1, 1891) — Corn: Cultural, variety and fertilizer tests. *Out of print.*

No. 28 (Vol. IV, No. 2, 1891) — Miscellaneous experiments in the control of injurious insects. *Out of print.*

No. 29 (Vol. IV, No. 3, 1891) — Fertilizers on wheat. *Out of print.*

No. 30 (Vol. IV, No. 4, 1891) — Wheat: Cultural and variety tests and treatment for smut. *Out of print.*

No. 31 (Vol. IV, No. 5, 1891) — The wheat midge. *Out of print.*

No. 32 (Vol. IV, No. 6, 1891) — Experiments with small fruits. Diseases of the raspberry and blackberry. *Out of print.*

No. 33 (Vol. IV, No. 7, 1891) — The Hessian fly. *Out of print.*

No. 34 (Vol. IV, No. 8, 1891) — Forty years of wheat culture in Ohio. *Out of print.*

No. 35 (Vol. IV, No. 9, 1891) — Apple scab. The spraying of orchards. *Out of print.*

No. 36 (Vol. IV, No. 10, 1891) — Tenth annual report. Meteorological summary. Index. *Out of print.*

No. 37 (Vol. V, No. 1, 1892) — Oats: Cultural and variety tests.

No. 38 (Vol. V, No. 2, 1892) — Mangel wurzels and sugar beets.

No. 39 (Vol. V, No. 3, 1892) — Fertilizers on corn and oats.

No. 40 (Vol. V, No. 4, 1892) — Insects which burrow in the stem of wheat.

No. 41 — Not published.

No. 42 (1892) — Wheat: Cultural and variety tests.

No. 43 (1892) — Greenhouses and greenhouse work. The food of the robin.

No. 44 (1892) — The rusts of Ohio. Wild lettuce. Scab of wheat.

No. 45 (1892) — Insects affecting the blackberry and raspberry.

No. 46 (1892) — Underground insect destroyers of the wheat plant.
No. 47 (1892) — Eleventh annual report. Meteorological summary. Index
No. 48 (1893) — Profit in spraying orchards and vineyards. *Out of print.*
No. 49 (1893) — Field experiments with fertilizers.
No. 50 (1893) — Experiments in feeding for milk.
No. 51 (1893) — Miscellaneous entomological papers.
No. 52 (1893) — Twelfth annual report. Meteorological summary. Index.
No. 53 (1894) — Field experiments with commercial fertilizers.
No. 54 (1894) — Strawberries. *Out of print.*
No. 55 (1894) — The Russian Thistle in Ohio.
No. 56 (1894) — The San Jose Scale.
No. 57 (1894) — Oats: Variety and cultural experiments.
No. 58 (1894) — Thirteenth annual report. Meteorological summary. Index.
No. 59 (1895) — Noxious weeds along thoroughfares and their destruction.
No. 60 (1895) — Feeding for beef.
No. 61 (1895) — Sub-irrigation in the greenhouse.
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This Station has also published four bulletins in a "Technical Series," the first three numbers of which are devoted to entomological and botanical papers, the last to a list of the birds of Wayne county, Ohio.

Ohio Agricultural Experiment Station.

BULLETIN 121

WOOSTER, OHIO, SEPTEMBER, 1900.

A CONDENSED HANDBOOK
OF THE
DISEASES OF CULTIVATED PLANTS IN OHIO.

The Bulletins of this Station are sent free to all residents of the State who request them. Persons who desire their address changed should give both old and new address. All correspondence should be addressed to

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The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.

Bul. 121

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 121. SEPTEMBER, 1900.

A CONDENSED HANDBOOK OF THE DISEASES OF CULTIVATED PLANTS IN OHIO.

BY A. D. SELBY.

INTRODUCTION.

Before enumerating the diseases of the plants we are engaged in cultivating, it is well to consider the significance of the term "disease" as applied to plants. As used herein, the term "plant disease" means any deviation from the ordinary or average condition or behavior of a plant in respect to appearance, growth, color of bark or foliage, fruitfulness, time of dropping leaves or length of life; in short, a plant is said to be diseased when it does not conform to those averages which we have established by extended observation for the species and variety in question. In this general sense certain particolored or purple hued sports would be included, although potentially rather than actually in diminished vigor; such sports, especially the variegated types, succumb easily to parasitic attack. The more usual symptoms of disease are marked by deviations of an evident character, such as spotting, curling, discoloration or dropping of the leaves at an unusual time, the spotting and decay of fruit, or by sudden dying or blighting of twigs and branches; in all these we have apparent loss of vigor and reduced profit. Yet we must not attribute all these to fungi and insects; purely physical causes may be at the bottom of certain troubles. Plants may be asphyxiated by too much water, which excludes air supply, when they have been habituated to dry soils; they may be likewise strangled by the escape of gases, especially in the case of shade trees in cities. Furthermore, quick growing plants like cucumbers may fall in drought if started during a period of excessive rains. Plants may likewise

be injured by winter freezing, by hail, by overbearing and a variety of other causes. Some diseases are yet obscure as to cause; Peach Yellows is a type of these.

While all this needs emphasis, the larger portion of the diseases considered on the following pages are directly attributable to parasitic fungi which attack the plant in some vital part and rob it of its substance. It does not suffice to call these diseases by the old name of rust, blight, etc., irrespective of the class of fungi concerned in the parasitic attacks. The rust fungi *(Uredineae)* cause diseases properly called "rusts." So likewise the smut fungi *(Ustilagineae)* cause the well known and destructive smuts upon grasses and cereals. The anthracnoses are produced by a definite class of fungi (the *Melanconieae)*. (Fig. 1). A like clearness of system in naming does not hold for all but system nevertheless prevails. To this end the common names applied have been selected in accordance with recognized usage.

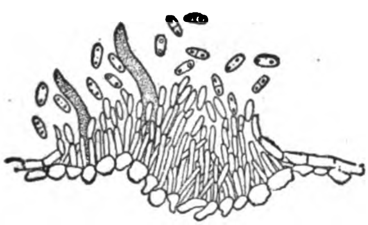

Figure 1. Section through an anthracnose spot (*acervulus*) of the cucumber anthracnose fungus (*Colletotrichum lagenarium*) showing the long, dark hairs (*setae*) of whose office we know little, the spore bearing branches (*fertile hyphae*) and the spores of this fungus. The members of that division of the commoner anthracnoses having setæ in the acervuli are referred to the genus *Colletotrichum*, while similar ones without setæ bear the genus names *Gloeosporium*, *Sphaceloma*, etc. (See anthraconses of apple, grape, lettuce, etc.)

The differences between the species of parasitic or other fungi are as strongly marked as those of higher plants, so that a discriminating system of naming diseases has a secure foundation. Further, respecting parasitic fungi, we must recognize that they are all derived by special processes of reproduction peculiar to the fungus in question; in other words, spontaneous generation does not find support among mycologists. The presence of any given fungus leads us at once to infer the previous existence, somewhere within reach, of a fungus of like species from which this one was derived by definite methods of reproduction. Likewise, the destructive prevalence of a parasitic fungus in any given time and at any given place, assures us of the necessary supply of spores to start the trouble again under favorable conditions. In fact, all our study leads us to look through mere phenomena, mere evidences of disease, to find the specific parasitic growth which causes them and the favoring conditions under which these develop. The spores of fungi serve for them the same purpose as do the seeds in higher plants; by reason of the extreme smallness of the spores they are easily transported by the wind and become deposited like dust particles upon exposed surfaces. Certain resting spores survive on the fallen leaves or other parts and will be destroyed if these parts are burned.

Some fungi survive by their thread-like parts *(Mycelium)*, like Canada thistle and mint among weeds by their underground stems. The bacterial diseases are propagated by minute germs, microbes, within the plants diseased, which gain entrance by the blossoms, or other openings of the plant. The water pores of cabbage plants permit the entrance of the microbes of cabbage black rot; while, in general, it may be noted that parasitic fungi of all classes may find entrance into the leaves and green stems through the stomates or breathing pores with which all these green parts are necessarily provided. (Fig. 2). All parts of higher plants which function as leaves have these stomates.

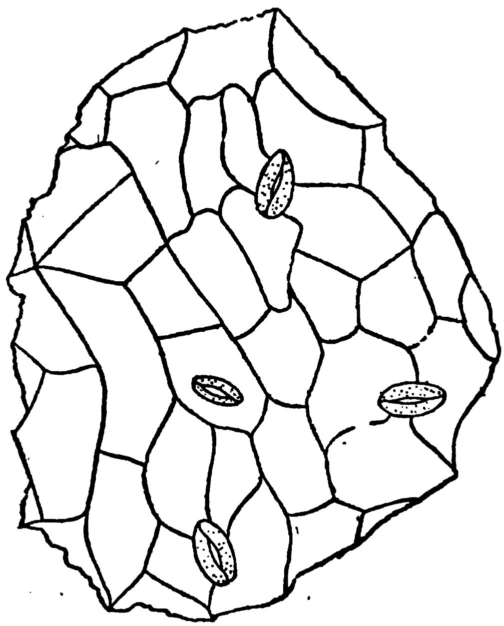

Figure 2. A portion of the epidermis from the upper surface of a cucumber leaf, showing the breathing pores (*stomates*) surrounded by guard cells containing chlorophyll grains, much magnified. These guard cells, which control the opening and closing of the stomates, are the only epidermal cells that contain this green substance, the others being colorless.

The remedies for diseases of plants are based upon the character and life history of the particular parasitic growth with which we have to deal, or in non-parasitic troubles upon the particular conditions which give rise to disease. These measures are based upon common sense reasonings derived from the known relation of cause and effect. If soil is too wet, drain it; if late growth predisposes to winter injury, avoid such growth; if overbearing weakens plants, prevent it by thinning the fruit.

In the domain of parasitic contagious diseases we have those measures which destroy the supply of spores or germs, as well as those which should avoid the conditions of danger by rotation and planting on new land. These are based on the known behavior of the parasites. In addition, we have the numerous instances of prevention by the use of fungicides; here we apply some substance which will destroy the spores already present, as in the case of grain smuts, or prevent their growth and parasitic development when deposited, as with fungous troubles generally, upon fruit and foliage. For the latter class we have found a certain nearly in-

soluble copper compound, copper hydroxide, which is produced in Bordeaux mixture, to remain longer upon these parts and be still more effective than any other compounds for such purposes. The insoluble, or slowly soluble character, is here a great advantage in extending the interval between applications of the fungicide.

As the ripening period of the fruit approaches more soluble compounds, which will not remain on the ripe fruit, will find application, but their effective period is shorter than for Bordeaux mixture. These measures are all preventive rather than curative. In all such matters the pathologist must work within the limitations prescribed by the behavior of the parasitic foes, and by the commercial and cultural conditions of the grower. The achievements in this line of remedies for fungous diseases have been remarkable within the past decade (See Bulletin 111 of this Station); the power of self-help given to the farmer and fruit grower by these investigations is certainly very great. These advances have made possible the summary of our knowledge of plant diseases and their remedies set forth in the following pages. It has been prepared in the hope that it may be of service to all citizens of Ohio concerned in the cultivation of plants of any class.

The illustrations in this bulletin have been largely drawn from the previous publications of this Station by Weed, Miss Detmers and the writer; small cuts have been made from certain larger illustrations while with others only a portion of the original cut has been used. Some of the illustrations are new and, unless otherwise designated, are from photographs by the writer. I beg to express my acknowledgments to Professors Halsted of New Brunswick, N. J., and Atkinson of Ithaca, N. Y., and to the Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture, for recent and past favors in the matter of cuts which are used herein. In all cases it has been the aim to state the source of these cuts in the descriptions. The same applies to illustrations reproduced from standard works.

CONCERNING PARASITIC FUNGI.

A fungus (plural, fungi) is a plant, a member of the class called fungi. The fungi are low in the scale of plant life, being classed with the algæ and other similar plant forms. They are lower still in the life scale than the mosses and liverworts; above the mosses come the fern-plants, and above these the seed plants, such as grasses, grains, clovers, trees, shrubs, herbs and the like, with which we come in contact every day. The fungi are distinguished from higher plants as well as from their nearer relatives, the algæ, by the absence of green color, and for that reason, we may assume, by the lack of power to prepare their own food from the mineral substances dissolved in water, and from the gases contained in the atmosphere. Herein they are marked off from most groups of plants: the fungi must live upon the substance of living or dead plants or animals. If they ever possessed the power of utilizing the same foods as most other plants, this ability has been lost. Parasitism is usually taken to indicate degeneracy in character. One way of regarding the fungi, is as algæ without chlorophyll, to which the latter owe their green color. As above stated, the fungi are, in the absence of chlorophyll, forced to live upon the dead remains of plants or animals, or to prey upon the living organisms.

CLASSES OF FUNGI.

Such fungi as subsist upon living plants or animals are called parasitic fungi. A parasite is one who eats at another's table and the adjective "parasitic" comes from this word, parasite. It is the parasitic fungi especially of which we must learn, since this class produce diseases when they attack other plants. The plant attacked is the "host" plant, however unwilling the entertainment of the sycophant.

Most fungi are very minute in size and require the use of a microscope to study their parts; certain ones, however, such as the mold upon bread or other foods, may be seen very easily to consist of fine, thread-like growths interwoven together, and bearing certain rounded parts upon erect branches. Some idea of fungus-structure may be obtained by studying these common molds; that on a discarded melon rind will show the parts above described, and by the use of a microscope we may learn that the rounded, ball-like enlargements just mentioned consist chiefly of small bodies that are capable of growing into other fungus-threads. (Fig. 3). Such min-

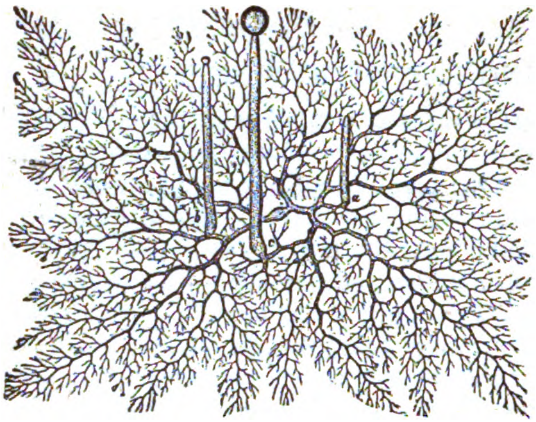

Figure 2. Mycelium of the common mold (*Mucor Mucedo*). From the spore lying near the middle of the figure, and strongly swollen, one sees the thick threads of the mycelium arise; these in turn become richly branched. There are no divisions in the mycelium. From the level of the mycelium arise three vertical, fertile hyphæ, *a*, *b*, *c*, of which *a* is still very young and that at *b* is already producing a sporangium containing many spores. All highly magnified. (After Zopf, from Reinke.)

ute parts capable of germinating and again producing the fungus are called spores. Most spores are very minute and are not heavier than the other dust particles carried by the wind. The spores of fungi are the means by which they are most commonly reproduced, somewhat after the manner that the higher plants about us are reproduced by their seeds.

While we have cited the bread mold as a good illustration to show the structure of a fungus, it is not a parasitic fungus; a mold or like growth which lives upon decaying material is called a saprophytic fungus. To this same class belong the mushrooms or toadstools that may be found in manure piles, in the woods and in orchards; the fact that we find them in such places shows that there is decaying organic substance at that point, upon which these plants may subsist. A like condition is found in the shelf-fungi on old logs and stumps, on the under surface of which we may write our names. Yet if we will use a hand lens we may often discover this under surface to be but a network filled with small openings or pores from which the spores of the fungus will in time escape. In like measure the spores of mushrooms are found in similar canals or upon the sides of the gills beneath the cap of this sort of fungus. The bacteria, or fission fungi, are one-celled plants multiplying by division and by spore production; with bacteria evident mycelium is lacking and they are structurally lower in the scale of plant life than fungi provided with a mycelium. Bacteria are both parasitic and saprophytic. But to return to parasitic fungi.

PARTICULAR FACTS ABOUT PARASITIC FUNGI.

Like the bread mold, or the other fungi just mentioned, parasitic fungi consist of a growth of threads or hyphæ (singular, hypha) which do the necessary work of getting food for the parasite; these also in due time give out certain branches destined to bear spores, somewhat after the manner that the pear tree has flower clusters, or the wheat

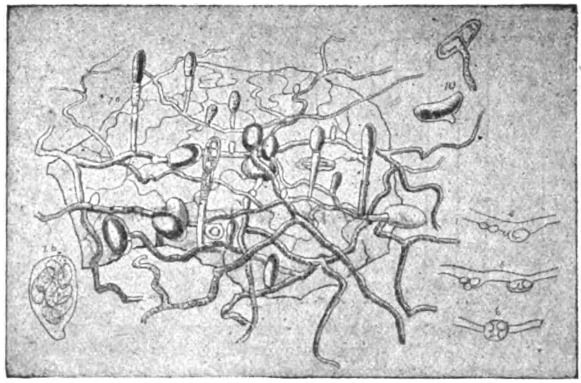

Figure 4. *7a.* A portion of leaf of pea showing breathing pores and parasitized by powdery mildew; the horizontal threads (*sterile hyphae*) and summer spore bearing parts of the mildew fungus (*fertile hyphae*) are distinctly shown. In these latter the septa are evident. *7b.* A spore sac (*ascus*) of the same fungus. 4, 5, 6, show the sucking organs (*haustoria*) of the sterile hyphæ of this fungus; these penetrate the epidermis of the leaf. 10 shows the spores of the rose mildew germinating. All highly magnified. (After Tulasne.)

NOTE — The stomate in foreground is distorted. See Fig. 2.

plant forms its dense spike of bloom, both of which are especially designed to produce seeds from which wheat plant and pear tree may in turn be grown. The essential parts of a parasitic fungus are these threads, or hyphæ, and the spores produced by them. The hyphæ of the fungus taken collectively are called the mycelium, which consists of threads that produce no spores (sterile hyphæ) and of those destined for spore production (fertile hyphæ). (Figure 4). It is to the food getting qualities of the hyphæ that the fungus owes its continual existençe, and they in turn arise from a spore or directly by the growth of some fragment of fungus-thread, as the Carolina poplar may be grown from a cutting. Yet, while all parasitic fungi are made up of these few parts, the differences in form and apparent structure among the several groups are very marked; differences exist as to the thickness of the hyphæ whether or not the threads are divided into separate cells by divisions like those at the joints of a bamboo rod, as well as in the manner of spore formation and in the size, color, form, markings and structure of the spores themselves. It is almost hopeless to undertake to illustrate types of spore production and spore forms, since these are so varied, and may differ so much at different stages of the development of a single given species of fungus, yet we may cite a few examples: —

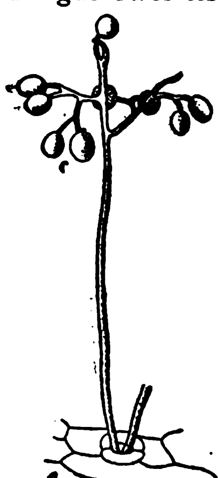

Fig. 5. Fertile hyphae (*conidiophores*) of the downy mildew fungus on *Cardamine*, a mustard, protuding from a stomate; the one shown in full, bearing spores at the ends of its branches. Highly magnified. Very similar to this are the downy mildews of grape, cucumber, lettuce and some others. (After Zopf.)

Fungus spores may be produced as single spores or in naked clusters attached to certain branches. We find this sort in the downy mildew of the cucumber and its relative the peronospora of mustards (Fig. 5); in potato early blight; in fruit rot of plum, cherry, peach, etc., and later in the spores in apple scab. They may also be

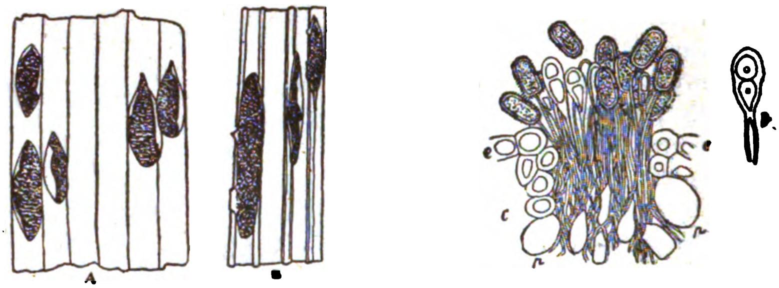

Figure. 6. Showing the common rust of oats and rye. At *A* a small fragment of rye leaf with several orange-red, rust sori breaking through the epidermis; these are of the earlier summer spores (*Uredo*) or red rust of popular speech. At *B* a small fragment of a rye leaf with several black, rust sori, elongated in form, breaking through the external covering; these are of the later summer or winter spores (*Teleutospore*). *A* and *B* slightly magnified. At *C* section through the uredo-sorus of *A*; on the slender stalks (*basidia*) the rough one-celled uredo spores, and between them a young, two-celled teleutospore, which later alone form the sorus. *e*, *e*, epidermal cells, *p*, *p*, cells of the leaf interior through which runs the mycelium of the fungus. At *D* a teleutospore from the black sorus of *B*; this is divided by a septum into two cells. Similar uredospores are found in most rusts; similar teleutospores occur in corn rust, wheat rust, etc., and in the spores of the cedar apple fungus. *C* and *D* considerably magnified. (After Zopf, from Frank.)

found in dense clusters breaking through the skin of the plant like the many tubers of a potato breaking through the earth-crust; such, without further conspicuous covering are found in the rust spots, in the anthracnoses and the like. (Figs. 1 and 6). These dense clusters may arise beneath a special covering resembling nothing so much as the traditional beehive, but are usually ejected forcibly from a specially provided opening at the top of the cone or half-ball. (Fig. 7). A yet more interesting class is that in which the spores are packed so many to a sac (usually eight) and a large number of these crowded into a ball-like hollow spore-case, such as we find in black-knot, strawberry leaf-spot, the powdery mildews and in some other instances. (Fig. 8). There is yet another sort in which the spore sacs are abundant near the surface of the diseased part, as in leaf-curl of the peach, where the maturity of the fungus is shown by the change in color of the affected leaf surfaces. Other gradations will be found as one proceeds in this study.

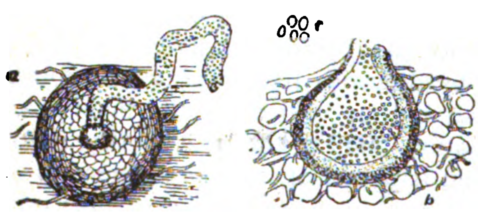

Figure 7. *a*, A spore-case (*pycnidium*) of a beet leaf-spot fungus (*Phoma*) seen from above and showing the slender, flexuous mass of spores, ejected from the pycnidium. *b*, section of a pycnidium, seated in the leaf tissues and filled with spores. *c*, a group of the spores. All highly magnified. (After Allescher from Delacroix.)

HOW THESE PARASITES ROB THE HOSTS.

There is an old saying about the stable door and the stolen horse; similar application may be made for plants and parasitic fungi

in a manner which we shall presently perceive. To obtain food we must reach the source of supply; the manner of reaching it is less important than the result. Now it occurs that cultivated and wild plants of the higher classes are wrapped about by a covering of skin or bark, and the food-filled juices are within; to feed upon any living host the parasite must gain access to the internal tissues of that host. It so happens that there are minute openings or stomates (breathing pores) through the skin of leaves and of young green stems; these openings are as necessary as the stable door, and through them the thief may enter. Were these openings to become entirely closed the plant would languish, and remaining open, they constantly offer a way for the slender tips of the growing germ thread of a fungus to push its way through the plant covering and to luxuriate within the host upon the substance of the plant. Once within, the fungus thrives, rapidly multiplies its branches, and if in summer, commonly thrusts its fertile threads through some of these breathing pores to bear its spores outside where they may become more widely distributed than if remaining within the tissues of the host plant. Should, however, the winter season be near, resting spores may be formed, or their formation be provided for within the leaves, or diseased parts, as in grape downy mildew, elm-leaf disease and in black-knot of plum and cherry. Thus the cycle of development continues indefinitely unless some agency intervene to destroy the spores, to prevent their germination, or the parasite itself so exhaust the host plant as to destroy it entirely and the fungus perish for lack of suitable nidus. However, this rarely occurs, not perhaps, so often as men are guilty of killing the goose which lays the golden egg. Herein, we meet another fact, namely, that parasitic fungi of a given kind are limited to a particular host plant of a certain species, or to a small number of related plants, so that if a congenial host is lacking the fungus will not thrive.

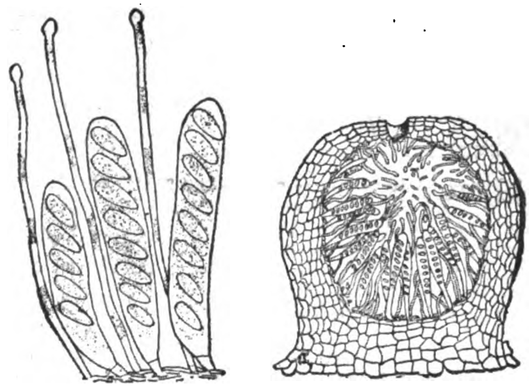

Figure 8. Section through a spore case *(perithecium)*, late winter stage of black-knot fungus, showing spore sacs *(asci)* within. Beside it, three asci containing winter spores or ascospores, eight in each sac, arranged in a definite manner. Along with these are threadlike hyphæ known as paraphyses.

The fungus threads growing within any plant will not flourish if simply passing between the cells of the host; penetrating organs

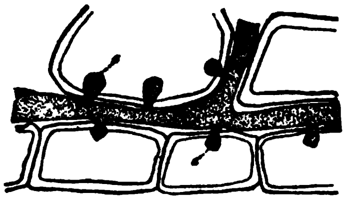

Figure 9. Haustoria of the fungus of the grape downy mildew penetrating cells of grape stem. The shaded portion shows the mycelium of the fungus growing between the cells, sending haustoria *a a* into the interior of the cells. (After Scribner from Farlow.)

Note — In this figure the lower row of cells have the form of empty epidermal cells in which the fungus would find little to subsist upon. Farlow's original figure does not give these cells such form.

pierce the cell walls and are able to absorb nutriment from the cell interior. (Fig. 9). The diverse forms of sucking organs, and the peculiar structures of fungus threads in these situations would in themselves require much study and investigation to present them properly. We must further conceive that a fungus may often penetrate the bark of a tree for example, if aided by rifts caused by freezing or similar disturbances, to say nothing of the openings offered by wounds, the breaking of branches, etc. Few parasitic fungi have that penetrating power of thrusting the haustoria through the plant covering such as we find in the case of the dodder that twines about and robs the wild herbs and shrubs of the woods and fields as well as the cultivated flax and clovers.

HOW PARASITIC FUNGI AFFECT THE HOST.

We know the cumulative effects of insufficient food supply; these effects must hold for plants attacked by parasitic fungi. Aside from the nutriment diverted to the parasite, there is reduced functional vigor of leaf, stem or root, and the loss becomes increased in this way. Let all the leaves be parasitized, or let even three-fourths of them be entirely so attacked, and we may look for great loss of foliage, possibly entire loss of fruit and the entailed effects of diminished vigor, unripened wood, or by repetition, entire destruction of the host. Usually the effects are of many gradations, but in all cases of leaf parasites the entire plant must suffer. We have learned that bacteria may, in a suitable medium, destroy themselves by the formation or emission of poisonous products which are fatal alike to the bacteria and to animals, or even man; that such takes place within plants parasitized by fungi remains in doubt, and may be disregarded for the present. The results of impaired function in the parts are serious enough to demand our attention. It is altogether probable that future investigations will modify our views upon some points.

There are many curious transformations and malformations resulting from the attacks of parasitic fungi. The branches of the plum and cherry become enlarged as a result of the attacks of black-knot, simply by the multiplication of cells of wound cork in the effort of the host to shut off the fungus, not because the fungus consists of such a mass of tissues. In a similar manner the leaves of the peach are thickened and "curled" by the leaf-curl fungus and the plums are made "bladders" by the fungus of plum pockets.

While exceedingly interesting to trace the effects of the white mold on shepherd's purse and on the garden purslane, as well as the effects of bramble rust, cabbage club-root and a number of others, the principle above pointed out will be found generally applicable; and it is to the reactions of the host plant that the excrescences or malformations are chiefly attributable.

It may further be stated that artificial cultures of parasitic fungi, either upon culture media or living plants are constantly adding to our knowledge in these lines.

DISEASES OF PLANTS.

AFALFA—LUCERN.

Leaf-spot fungus: — This forage plant is grown in parts of Ohio. It is attacked by the leaf-spot fungus[1], which is found upon both leaves and stem. The small dark spots produced by it are easily seen. In attempts to produce afalfa seed at this Station, the fungus has stripped leaves and seed capsules before maturity. It is very likely to prevent success in growing this seed in Ohio, though it is much less injurious to the forage crop proper.

APPLE.

Bitter Rot or Anthracnose[2]: — This disease is most common on Bentley Sweet and some other, chiefly sweet, varieties. The fungus appears upon the apple later than the apple scab and affects both the eating and keeping qualities of the fruit. In Virginia (Bulletins 17 and 40, Va. Exp. Sta.) spraying with fungicides is recommended. For details see spray calendar. The Bitter Rot of the Baldwin causes small sunken spots in fine fruit of this variety. It is attributed to a different fungus.[3] Orchardists who have reported to this Station upon this disease state that it is not prevented by spraying with Bordeaux mixture. At New Hampshire Experiment Station (Bulletin 45) successful prevention with this fungicide has been reported. The trees were sprayed four times, twice before and twice after blossoming. Also once before and twice after blossoming: 3 percent of the sprayed fruit was spotted with the disease while 55 percent of the unsprayed check trees was spotted. The chief gain appears to be in spraying after blossoming. A spotting of the Baldwin attributed to non-parasitic conditions is described by Stewart (N. Y. Bul. 164). Internal brown spot on Northern Spy and Fameuse or Snow apples, also on some other varieties, is at times complained of. The marketable quality of the fruit is much impaired. The exact

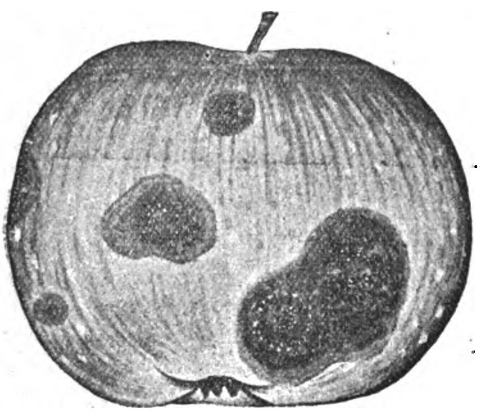

Figure 10. An apple attacked by Bitter-Rot. (After Alwood.)

[1] *Pseudopeziza medicaginis* (Lib.) Sacc.
[2] *Gloeosporium fructigenum* B.
[3] *Phyllachora pomigena* (Schw.) Sacc.

cause of the spotting is not known; it appears possible that it arises from impaired vigor of trees, either through lack of cultivation and pruning or from overbearing, etc.

Crown Gall: — This disease, shown in Figure 11, causes enlargements near the ground on nursery apple trees and is still somewhat obscure. It appears to be in part, at least, due to the same cause as the crown gall on raspberry and peach (which see). It is at times not easy to separate this trouble from the effects of woolly aphis upon the nursery stock. Enough appears to be known about this disease to recommend the destruction of all stock thus affected. Soil which causes this sort of growth upon peach trees in the nursery has been known to produce the same upon the apple, and conversely. Cure of diseased trees, even if attained, is likely to cost more than the value of the stock. For the nurseryman such land needs rotation in corn, clover and other crops. In all cases the crown gall stock should be burned.

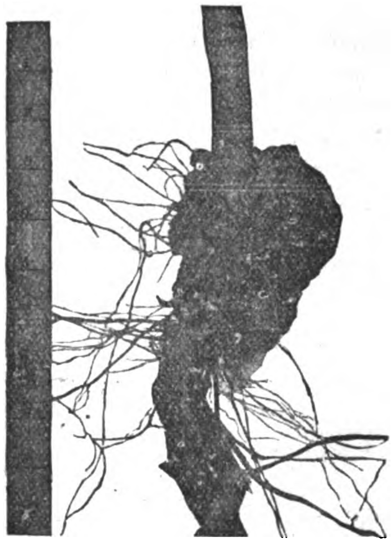

Figure 11. Crown Gall of apple on nursery stock.

Sooty Fungus and Fly-speck Fungus:[4] — This unsightly fungous disease in ordinary seasons appears chiefly upon apples grown in low, moist situations. Peck's Pleasant, Rhode Island Greening, Rome Beauty and several other varieties have been notes as affected by the Sooty or Fly-speck fungus. During wet seasons, like that of 1896, a few susceptible varieties are liable to be spotted by this parasite whatever be the location of the trees. It is thought by several that the fungus spreads upon the fruit after it is stored; but at whatever time it grows the spots make the apples dull, unsightly and unsalable. Aside from selecting high, sunny situations for the apple orchard, spraying with Bordeaux mixture will prevent this spot. One spray-

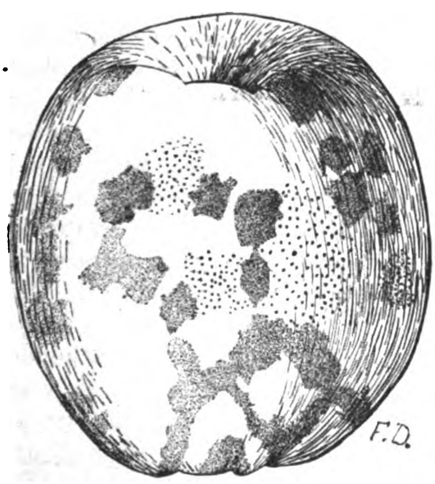

Figure 12. An apple attacked by Sooty and Fly-Speck Fungus.

[4] *Leptothyrium pomi* (Mont. & Fr.) Sacc.

ing may, at the time the apples are the size of hickory-nuts, prevent all or nearly all of the injury. Upon varieties like Maiden's Blush, Grimes and Belmont, the spraying should be done a little earlier than just stated.

Local Blighting or Sun-scald; Canker: — This local dying of the branches and trunk of apple trees, as if blighted upon one side, is a frequent source of injury to apple orchards in northern Ohio. Upon young trees the trunks are more commonly blighted in this manner and for this trouble the term "sun-scald" is often used. The disease is not confined to any section, though more prevalent at the North. Upon many sorts the branches are locally blighted and in time that portion beyond the injured area dies. The cause of this form of "canker" is traced by Paddock (1898, also B. 163, N. Y. Ex. Sta.) to the Sphæropsis[5] fungus which attacks the fruit and leaves of the quince and the fruit of apples also. (Fig. 13). From Oregon Cordley (Bull. 60, Ore. Exp. Sta.) has described an anthracnose[6] of the apple which produces similar results on the Pacific coast to those referred above to apple canker in our region. It has sometimes been observed that this form of injury is more frequent upon the south or southwest side of the tree — trees leaning to the northeast are often injured from below. Some varieties, as the Duchess and Grimes, are said to be more susceptible. Professor Burrill (Report of the University of Illinois 1876) shows that these injuries are due, in part, to winter freezing, which prepares the way by rupturing the outer bark: but more largely to the bacterium of pear blight, which then enters and inflicts the injury stated. Winter protection of the trunks of small trees may prove useful. During winter, injury in which the bark is separated from the trunk of apple, pear and peach trees, is often still more disastrous than the local blighting just mentioned. Should any condition, such as very warm fall rains following mid-summer drought, or late growth due to any

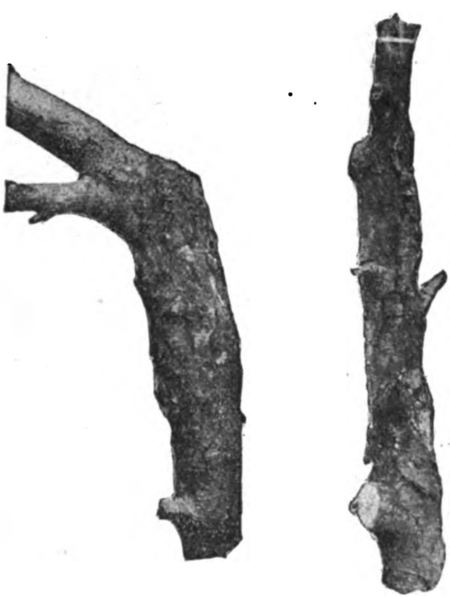

Figure 13. Apple branches attacked by Canker.

[5] *Sphaeropsis malorum* Berk.

[6] *Gloeosporium malicortis* n. sps.

cause, such as late cultivation, which is occasionally practiced, be followed by very severe cold in the winter, ice may form between the bark and the wood of the trunk and these so separate as to render growing together again, or healing, unlikely. Such injuries are often severe and may destroy in this manner all of particular varieties, as has occurred. Grimes's Golden, King of Tompkin's County and some other sorts, even in ordinary winters seem to die on one side of the trunk just above the surface of the ground. This injury, while not confined to any side of the trunk, is most common upon the south and southwest. In such cases winter injury may prove the cause. For protection, mulches and casings of straw seem worth trying. It is hoped that we may have observations reported upon the occurrence of toad-stool fungi about the diseased King apple trees.

Twig Blight: — This disease of the apple, caused by the bacterium of pear blight,[7] is often very prevalent. The microbe enters through the blossoms, being propagated in the nectar after infection by insect visitation. It destroys the blossoms as well as small twigs of the tree. Beyond the injuries just noted this microbe may gain entrance through the bark. (See sun-scald). The twig injury is not very great from this cause on the apple, though the small dead twigs are unsightly. The prevention will lie in the destruction of all the blighted parts on apple, crabapple, pear and quince trees in the vicinity. For fuller discussion see pear blight. In substance, this treatment consists in cutting out all blighted portions in fall and early winter and burning them to kill the resting forms of the microbe.

Root-rot: — A decay of the lower roots of apple trees is reported from Missouri. This may possibly be with us, especially in clay soils.

Scab: — Apple scab fungus[8] is a common source of large losses in Ohio apple orchards. It attacks first the leaves and afterwards the young fruit, causing it to drop. Aside from injuring the salability of the crop obtained and reducing the vigor of the tree by reason of its attacks on the foliage, *scab may prevent a crop altogether because of this dropping of the young apples.* The Ohio Station was in the van of progress in studying this disease, and the work has been steadily followed (Bulletin Vol. IV, No. 9, (1891) B. 79, (1897) B. 111, (1899).) Full details may be found in the various bul-

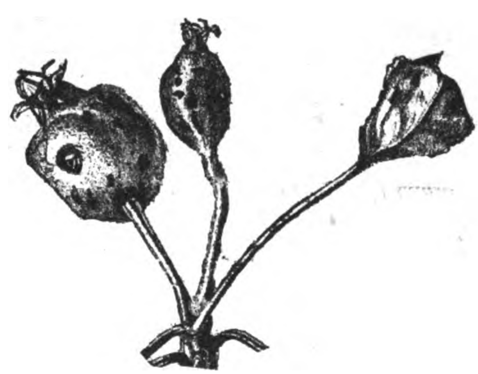

Figure 14. Young apples attacked by the Scab Fungus.

[7] *Bacillus amylovorus* (Burrill). [8] *Fusicladium dentriticum* (Wallr.) Fckl.

letins given. Apple scab develops when moisture is abundant during the early months of the season, and low temperatures are usually prevalent at such times. The dropping of apples often attributed to lack of pollination seems more often to be ascribed to the work of scab. All varieties are attacked by scab but some suffer more than others.

The profits from spraying for scab on the apple (including apple worms) have generally been large, because saving the amount of crop and enhancing its market value at the same time as well as increasing the number of crops. In this way the crops of a single orchard have been sold for a gain of about $1,000.00 on an expenditure of $125.00 to $150.00. At the Station this gain has amounted to $5.00 per tree (B. 111). The best fungicide for this purpose is dilute Bordeaux mixture, or Bordeaux I of the spray calendar, containing 4 pounds of sulfate of copper and 4 pounds of quicklime to 50 gallons of mixture with water. The first spraying should be made as the buds are swelling, the second just before the blossoms open, and upon the young leaves, and the third after the blossoms drop, with additions of arsenites in the third and a possible fourth spraying as stated in the spray calendar.

ASPARAGUS.

Rust: — In the east and in Europe the rust of asparagus,[9] proves to be destructive, and has just made its appearance at many points in Ohio. (See N. J. Exp. Sta. Report, 1896, and Bull. 129; Conn. Exp. Sta. Report, 1896, and publications of other contiguous states). The rust causes appearance of unusually early maturing of the plants. Closely examined, the rusted plants show blister-like spots on skin of the stem, and underneath these ruptures there is brown color due to the spores. The rust also assumes another form, the cluster-cup stage, which may be found in early spring with different color on volunteer plants; indeed the æcidial, or cluster-cup, uredo and teleuto-spore stages succeed each other on the stem. The usual recommendations are to burn the rusted bushes in autumn and to spray with Bordeaux mixture; this latter "reduces the amount of rust about one quarter." (N. J., B. 129). The Leopard spot of asparagus stems is apparently not infrequent, and the anthracnose of asparagus, which produces very small specks upon the

Figure 15. Asparagus attacked by Rust.

[9] *Puccinia Asparagi* DC.

stem, may also be expected, yet neither of these compares with the rust in destructiveness, nor does the rust of any other plant appear to surpass this in its ravages. The Palmetto variety is reported less susceptible to rust than any other sorts.

BARBERRY.

Rust: — The rust upon the barberry bush[10] is but a form or stage, the æcidial or cluster-cups, of the wheat rust.[11] The increase of virulence in the rust of wheat and rye, when grown near barberry bushes, was long noted before the demonstrated alternation of the fungus from the barberry to the wheat was proved in our century by De Bary. The barberry hedge is objected to, at times, by adjacent wheat growers, although we continue to suffer from the ravages of wheat rust many miles from any barberry bushes. In the absence of barberry the rust survives without it.

BARLEY.

Smuts: — Two barley smuts are recorded in our district, covered barley smut[12] and naked barley smut,[13] although no considerable losses have been reported from them. In these the heads smutted by the former are stated more commonly to remain enclosed by the upper leaf sheath; a membrane likewise holds the smut masses of spores in this species, while the spores are exposed and freely scattered by the wind in the latter.

In the prevention of barley smuts it has been found (Kansas Exp. Sta. Report, 1889; Yearbook U. S. Dept. of Agric., 1894; Farmers' Bulletin, No. 75, U. S. Dept. of Agric.) that the seed barley should be soaked in cold water for four hours, set aside four hours more in wet sacks, and then treated for five minutes in hot water at 130 degrees F. or 2 degrees lower than for wheat.

Rust: — This disease may be either an adaptive form of the ordinary grain rust, or it may be a more or less distinct species.[14] Its prevention has not yet been attained.

BEAN.

Anthracnose: — The anthracnose of the bean causes unsightly spotting of both pods and growing organs and is referred to the anthracnose fungus.[15] This species is also regarded as the same one that attacks cucurbits, including cucumbers, watermelons, muskmelons and gourds. The spotting of the bean pods is looked upon, too commonly, as a natural phenomenon. Measures looking to its prevention have

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[10] *Aecidium Berberidis* Gmel.

[11] *Puccinia graminis P. rubigo–vera* &c.

[12] *Ustilago Hordei* (Pers.) Kell & Swing.

[13] *Ustilago nuda* (Jens.) Kell & Swing.

[14] *Puccinia graminis* form simplex; or *Puccinia simplex.*

[15] *Colletotrichum Lagenarium* (Pass.) Hals.

not found ready application by growers. That fungicides are effective in reducing it we have reliable testimony (N. J. Exp. Sta. B. 108). The recommended treatment begins by soaking the seed 1 to 2 hours in ammoniacal copper carbonate, 1 ounce of copper carbonate to 1½ gallons of water. Bordeaux mixture is to be sprayed upon 2 and 3 inch plants, followed by the same 10 days later, and again repeated after blossoming of plant. (See Spray Calendar).

A Bacterial Blight has been reported from New York (N. Y. Exp. Sta. B. 181) and New Jersey (Exp. Sta. Rept. 1892) which promises more or less injury. In this malady the diseased parts, leaves, pods, etc., show characteristic, often watery spots. It is less prevalent on fresh land.

Downy Mildew: — This fungus,[16] so far as known at present, has not been found in Ohio, though occurring to a destructive extent in the east, and liable to occur in our vegetable gardens. Experiments have shown that it is controlled by spraying with Bordeaux mixture. (Conn. Exp. Sta. R. 1897, Pt. III). In this instance, as with the downy mildew of cucumber, it is probable that August 1 is sufficiently early to begin the application of the fungicides.

Powdery Mildew of the bean is due to the same fungus as the powdery mildew of pea, which see page 41.

Rust: — This fungus[17] is often observed to produce reddish brown spore masses upon both surfaces of the leaves of beans. It is perhaps rather more variable in occurrence, and certainly less injurious in the past than bean anthracnose. It has been quite common in Ohio. Beyond burning diseased refuse we are not prepared to suggest remedial or preventive measures.

BEET.

Leaf-spot: — The garden beet is quite liable to the attacks of the leaf-spot fungus[18] which causes serious impairment of leaf action and premature dropping of the foliage. Other changes are likely to follow those stated. This trouble may be controlled by the use of Bordeaux mixture at fortnightly intervals. (B. 102). The leaves of beets are also attacked by a white mold,[19] although this latter fungus is less frequent and less ruinous than that of leaf-spot. The same fungicide may be used if required. (See "sugar beet" for other diseases).

BEGONIA.

Nematodes: — These minute worm-parasites attack the roots and also the leaves of cultivated begonias (Ohio Exp. Sta. B. 73; N. J. Exp. Sta. Report 1894). For the commoner root injury avoidance is to be sought in the preparation of the earth.

[16] *Phytophthora Phaseoli* Thaxter.
[17] *Uromyces appendiculatus* (P.) Lév.
[18] *Cercospora beticola* Sacc.
[19] *Cystopus Bliti* (Biv.) Lév.

BLACKBERRY.

Anthracnose: — The anthracnoses of blackberry and raspberry[20] are identical and are described under the raspberry.

Leaf-spot: — This disease is also common to the blackberry and the raspberry, although the latter is less commonly attacked. This fungus[21] is conspicuous upon the wild growth and upon the trailing dewberries; it produces, usually, small, light-gray spots in the leaves and yields to treatment with the standard fungicide. (See Ohio Exp. Sta. B. IV, 6, and B. 79).

Crown Gall: — Is apparently of a similar contagious nature to that of the raspberry. It is of like appearance, though the galls at the crown of the plant are often larger. A plant once attacked is incurable, and offshoots from it appear to be generally affected, thus calling for immediate digging and burning of all the diseased canes and the abandonment of propagation from such plantations. (See raspberry crown gall).

Red Rust or **Bramble Rust**[22] is a well known disease of the wild and cultivated blackberries, which also attacks raspberries. It causes the affected leaves to turn first yellowish in color, remain erect in position, and finally to become bright red with an abundant coating of the spores of the rust fungus. These spores are readily scattered and may thus affect previously healthy plants. The threads of the rust fungus (mycelium) live year after year in the affected plants. For this reason the only remedy is to dig and burn all members of the rusted stools. (See Bulletin 79).

BLUE GRASS.

This, our best pasture grass, is an object of marked interest and solicitation. Its blades are attacked by the same **smut**[23] that is found on timothy, though destructive on neither. It causes sooty growth along the blades. This grass is also whitened at times by the conidial stage of the **wheat mildew**,[24] and is likewise susceptible to certain **rusts** that are destructive upon our grasses.

BROOM-CORN.

Smuts: — Of these there are two, head smut[25] and grain smut,[26] the latter of which is prevented by treating seed for 15 minutes in hot water at 135 degrees F. and drying for planting as for oats. The same smuts attack sorghum and are very likely to occur in foreign seed. (See Kan. Exp. Sta. B. 23; Ills., B. 47).

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[20] *Colletotrichum venetum* (Speg.)
[21] *Septoria Rubi* West.
[22] *Caeoma nitens* Schw.
[23] *Tilletia striaeformis* West.
[24] *Erysiphe graminis* DC.
[25] *Ustilago Reiliana* Kühn.
[26] *Cintractia Sorghi-vulgaris* (Tul.) Clinton.

BUCKWHEAT.

Leaf-blight: — This well known plant is frequently attacked by a leaf-blight fungus[27] which produces whitened areas on the under leaf surfaces and causes dying of these leaves. It is not known to be sufficiently destructive to warrant treatment for prevention.

CABBAGE — CAULIFLOWER.

Brown Rot is a serious disease of these two crucifers, and attacks others of the family, including turnips. It is a veritable scourge to the cabbage growers of Ohio and other states. Smith (Farmers' Bull. 68, U. S. D. A.) has published concerning it and has attributed the disease to a specific germ.[28] The diseased heads may be dwarfed, in portions rotted, and brown colors will appear in the woody layers of the plant, including the stem. Badly diseased heads emit a penetrating and offensive odor. The losses from the brown rot have been very large and specific remedies cannot be stated. The author quoted sums up the subject of treatment in one word — prevention. The measures recommended are — plant on new land and only from healthy seed beds; avoid succession of the same crops; avoid stable manure and give preference to artificial fertilizers to escape possible infection through the manure. Prevent animals from cropping in diseased fields. Clean tools by scouring bright after use in infected soil. Fight the cabbage insects, since these inoculate healthy plants with the disease. Removal of badly affected plants, or newly infected leaves, at intervals, and subsequent burning, or deep pitting of this refuse may aid in checking brown rot. Destroy all mustard weeds.

Club-root: — Club-root fungus[29] attacks these plants as well as the turnip, ruta-baga, wild shepherd's purse, hedge-mustard and certain other plants of the mustard family. It causes enlargement of the roots and prevents growth of normal head or root. (See figure).

This fungus is harbored in the soil, so that if the land is once infected the disease may prove lasting. It has not yet been learned how long the trouble will survive if the soil is planted in other crops. Lands newly brought under cultivation may be infected with club-root through the wild mustard plants upon them. It would appear possible by watchfulness to avoid getting the club-root fungus into cabbage lands; the seed bed should be most carefully guarded from this trouble as from rot. It will be much cheaper to abandon the crop for some other, when the plant bed has become affected with club-root and the seedlings have enlarged or whitened roots from this disease.

[27] *Ramularia rufo-maculans* Pk.
[28] *Pseudomonas campestris* (Pammel)
[29] *Plasmodiophora Brassicae* Wor.

In New Jersey, Halsted has investigated this trouble and has found (N. J. Exp. Sta. B. 98 and 108) that fresh stone-lime, if applied at the rate of 75 to 80 bushels per acre upon freshly plowed land in spring, and worked into soil, will very greatly reduce the amount of club-root on turnips and cabbage; there is no reason to doubt that

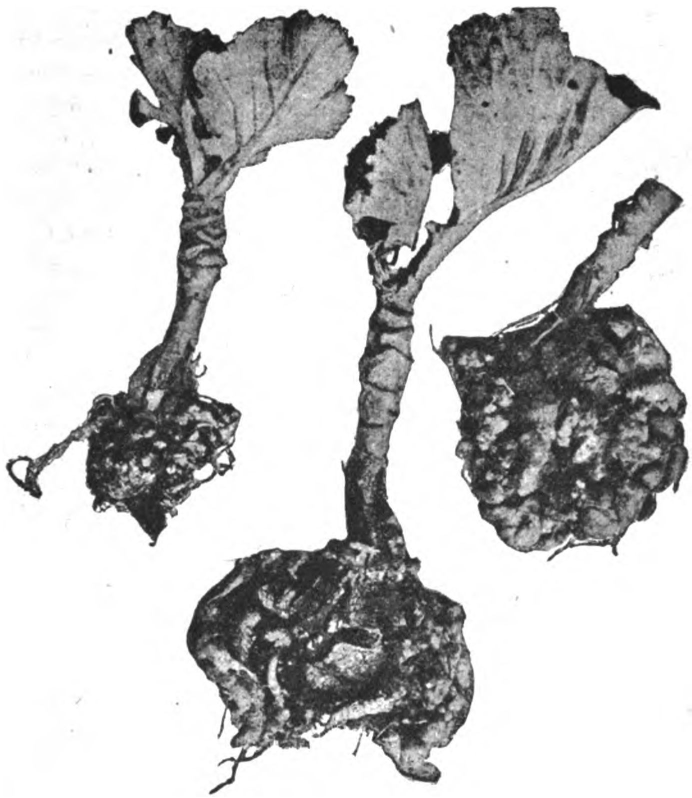

Figure 16. Young cabbages badly affected with Club-Root. (After Halsted, Bul. 98, N. J. Exp. Station.)

this treatment is applicable to all plants of the order attacked by club-root.

Downy Mildew,[30] **Leaf-Blight**[31] and **White Rust**,[32] occur upon the mustard plants, including, perhaps, all named above and some others. As yet their presence has not proved a serious drawback. If to be treated, Bordeaux mixture should be applied.

CALLA.

A **Root rot** of callas is under study. The disease appears to be due to bacteria (N. J. Rept. 1893). Reject rotted roots.

[30] *Peronospora parasitica* DeBy.
[31] *Macrosporium Brassicae* Berk.
[32] *Cystopus candidus* (P.) Lév.

CARNATION.

Leaf and **Calyx Mold**[33] of carnations is often very unsightly upon the calyces and pedicels of these flowers; it also attacks the leaves. All sorts appear to be more or less parasitized with the fungus in the houses where it prevails. Yet another spotting is produced by the carnation leaf-spot[34] fungus, which has appeared at this Station more frequently upon the Daybreak variety. It is believed that both these fungi will yield to treatment with Bordeaux mixture as per calendar. (See Bulletin 73).

Bacteriosis of carnations has been reported upon by Arthur and Bolley (Ind. Exp. Sta. B. 59). This causes many small, brownish spots with yellowing of the leaves of the affected plants. Such are feeble in growth and deficient in return. The maintenance of best and most favorable growth conditions may often be effective in preventing this trouble; particularly sub-irrigation and war on aphides are to be recommended.

Carnation Rust:[35] — This rust fungus is one of the serious diseases of the carnation. There is some difference in the liability of varieties to the disease, and perhaps a much larger difference in the condition of the stock plants from which cuttings are made. Assuredly this matter of "cutting-stock" is of very great importance and one admitting of selection of the very best plants. Experiments conducted at this Station in 1896 by the writer and the Station Florist (See B. 73) yielded no gain from spraying with Fowler's solution, which has been sometimes recommended. Watchfulness in the destruction of rusted parts, and in the stock for propagation, are suggested for the control of rust.

A **Stem** or **Root rot**[36] of carnations has been noted by Stewart (Bot. Gaz. XXVII, 129, 130) and occasional rotting of the flowers through the presence of a Botrytis. For the former no thoroughly effective remedy is now at hand, while general cleanliness of the house is necessary to avoid the rot fungus (Botrytis). (See Lettuce rot).

CARROT.

Leaf-spot: — This spotting of carrot leaves is usually caused by the same fungus[37] as the celery leaf-spot. Upon the carrot the trouble is not usually serious.

[33] *Heterosporium echinulatum* (B.) Cke.
[34] *Septoria Dianthi* Desm.
[35] *Uromyces caryophyllinus* (Schrank.) Schroet.
[36] *Rhizoctonia* and *Fusarium*.
[37] *Cercospora Apii* Fres.

CEDAR.

Cedar Apples or **Cedar Rust:** — During the showers of April, May or June, large or small, jelly-like masses, often one inch or more across, with firmer wood-like centers, are frequent upon red cedar trees and upon similar related plants. Microscopic examinations of these jelly masses show that they contain the spores of a rust fungus.[38] This fact need not startle us but for another, namely, that this is the completed or teleutospore stage of a rust which may seriously injure the leaves of the apple. The apple grower will run some risk then, in having about him diseased cedar trees. The remedy lies in the destruction of the cedar trees.

Figure 17. Red Cedar twig with Cedar Apple or Cedar Rust.

CELERY.

Black Root, so-called, may be found on celery plants from seed beds. In one instance such plants yielded growths which shortly run to seed and were valueless.

Leaf-spot or Leaf Blight[39] is a prevalent condition upon celery plants. This is at times attributed to the fungus above named, or others,[40] and is also produced by other causes, as by excess of water during overflow and the like. During certain seasons the loss from the leaf-spot or leaf-blight troubles is very much greater than during others. This is clearly explained when the conditions giving rise to the leaf troubles are apparent. But this is by no means a common fact, and in some years there is much blighting after the celery has been boarded up for blanching. Usually the fungus is discoverable in diseased areas of the leaves. The use of fungicides, such as Bordeaux mixture, is likely to prove beneficial, especially to protect the plants in the seed bed until transplanted. (See Spray Calendar). While beneficial for later ap-

Figure 18. Celery leaf attacked by Leaf-spot.

[38] *Gymnosporangium macropus Lk.* and other species of Gymnosporangium.

[39] *Cercospora Apii* Fres.

[40] *Septoria petroselina Apii;* (Desm.) Brio. & Cav.

[41] *Phyllosticta Apii* Hals.

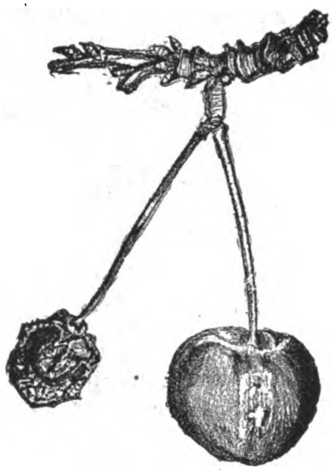
Figure 21. Rotted and sound cherries.

of cherry diseases to the commercial cherry grower. The decay of the fruit is caused by the fungus named. The conditions of the season may favor or retard the spread and development of the fungus. The threads of the fungus (mycelium) survive in the rotted fruits, which may hang on the trees unless removed. Careful removal of all rotted fruit and spraying for the fungus, as per the calendar, may be relied upon to save a part of the fruit, but judgment and attention to the details of the work are always required. It is to be understood, also, that checking the curculio is a mere means of helping to check rot.

CHESTNUT.

Anthracnose is a disfiguring spotting of chestnut leaves, about which inquiries are often made. Small, dead areas with characteristic borders are produced by this fungus.[49] Such applications of fungicides as are made for shot-hole fungus of the plum and leaf-spot of the horse chestnut, will be found useful when treatment becomes necessary on the chestnut.

CHRYSANTHEMUM.

Leaf-spot is frequently a disfiguring disease of this plant in earlier growth. It is caused by the leaf-spot fungus.[50] Two other fungi, a Phyllosticta and a Cylindrosporium, also attack the chrysanthemum. For indoor treatment copper sulfate solution of one-fourth of the strength given in the spray calendar — that is one pound to 50 gallons of water — will prove available. More applications will be required, but the foliage will not be rendered so unsightly as with Bordeaux mixture which, however, may be applied in full strength.

Rust: — This is found on the chrysanthemum, resembling other rusts in its development. Rusted leaves and badly rusted plants should be destroyed.

CLOVER.

Dodder: — Clover dodder[51] is a parasitic seed plant increasing in frequency. It destroys patches of clover or alfalfa where present. (See Weed Seed Illustrations and Bulletin 83).

Rust: — The various sorts of the cultivated clover, Red, Alsike, Mammoth, etc., are attacked by a clover rust.[52] If one will examine

[49] *Marsonia ochroleuca* B. & C.
[50] *Septoria Chrysanthemi* Cav.
[51] *Cuscuta Epthymum* Mürr.
[52] *Uromyces Trifolii* (A. & S.) Wirt

the small, dark spots in the clover leaves he will find a cluster of this reddish fungus beneath. This rust does not spread to other plants than clovers and is commonly regarded as more disfiguring than destructive. It is not nearly so injurious as the leaf-spot of alfalfa which is similar in appearance.

Root Nodules and **Root Tubercles upon Leguminosae:** — Upon removal of the roots of the clover plant from the soil one finds minute enlargements which are the subject of frequent inquiry. These are nodules or tubercles as they were formerly called, caused by the messmate-living of certain nitrifying organisms, or microbes, with the clover plant. To these microbes in this communal life is due the power of withdrawing nitrogen from the atmosphere and fixing it in the tissues of the clover plants. The same applies in general to the nodules upon plants of this order, the *Papilionaceae*. It thus follows that these nodules are the normal condition of properly nourished leguminous plants of the order *Papilionaceae*, and it likewise follows that the full value of this work of nitrogen fixing is only realized for manurial purposes when the tissues of the clover plants decay in the soil.

CORN.

Bacterial Disease: — This has been described and illustrated in Bulletin 6 of the Illinois Experiment Station, 1889. The malady infests both younger and older plants. In the younger it causes a yellowish coloring and a general appearance of debility, with death of the leaves, commonly from the joint backward. After midsummer, spots appear on the exterior of the sheaths which are more conspicuous on the inner side and at times more or less smeared with a gelatinous substance. No successful remedy has as yet been proposed.

The Leaf Blight Fungus[53] has been noted in corn and has recently been sent to this Station from Vinton county, in the latter case upon sweet corn. The fungus causes somewhat extended, or elliptical brown (dead) areas in the leaf blades, readily identified by the microscope. All diseases of the young corn attract notice, but it is not certain that there is need to apply fungicides for this fungus, though such might prove successful.

Corn Rust[54] is met with in greater or less abundance upon corn every season, the greater abundance usually being in rainy seasons. The rust causes small oblong or elliptical spots on the surface of leaf and sheath and in the spots are contained reddish-brown spores of the rust. The shade of the spores will vary with the time and develop-

[53] *Helminthosporium graminum* Rab.

[54] *Puccinia Maydis* Berang.

ment of the fungus. Here, as with wheat, the fungus passes through the uredo and teleuto stages.

Corn Smut is a well known disease, attacking leaves, shoots, ears, tassels and brace-roots of corn, converting the diseased parts into masses of dirty (smutty) spores of the fungus.[55] A brief article upon corn smut will be found in Bulletin 78. (See also Bul. 92 of the Kansas Experiment Station.) The corn smut may be propagated by smutty seed, although much more likely to be carried by the transportation of the yeast spores of this smut fungus which may alight upon any young, growing part and produce smut infection. From this reason and from another — probably a greater prevalence of the smut yeast spores in later summer — later growing parts, for example, tassels, brace-roots, ears and sucker shoots, are perhaps more often attacked by the smut. The smut spores may be scattered in manure if smutted fodder is used, and it seems well proved that manured land yields more smutted corn than unmanured. The same may be true of clover sod as compared with corn stubble. The reason would exist in the decayed vegetable matter, wherein the secondary yeast spores of the smut may grow and then may be carried to the corn which becomes thus affected. Treatment of seed corn does not apparently reduce the amount of smut. Cutting and burning the smut boils before they have burst open would be useful. It is worth while to fight smut by all available means.

Figure 22. Ear of corn partly smutted.

CRAB-APPLE.

Scab:— The same scab which attacks the common cultivated sorts also attacks the crab-apple, including both fruit and foliage. The remedy is that given under apple.

CUCUMBER.

Anthracnose:[56] — This fungous disease attacks nearly or quite all cucurbits as well as the bean. Upon the cucumber in Ohio it is apparently more destructive during the earlier season. The fungus

[55] *Ustilago Zeae* (Beckm.) Unger.
[56] *Colletotrichum Lagenarium* (Pass.) Hals.

may be found in the greenhouse at all cultural periods, as well as in the field. It causes circular dead spots in the leaves, usually more than one-fourth inch in diameter, and likewise elongated brown areas on the stem. (See Bulletins 73, 89 and 105). Unlike the downy mildew, anthracnose may be checked after it appears, though best prevented by earlier applications of the fungicide. In the field, Bordeaux mixture is to be preferred; in the greenhouse, copper sulfate solution, one pound to 50 gallons, has proved efficient and has checked the anthracnose after one-fourth of the plants had been destroyed by it.

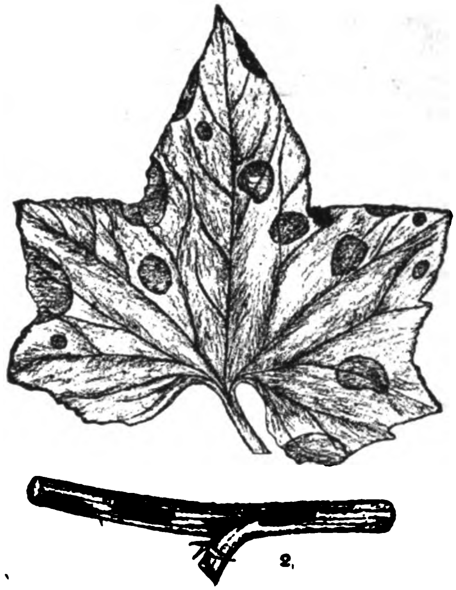

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Figure 23. Cucumber leaf and stem attacked by anthracnose.

Downy Mildew: — Downy mildew fungus[57] is late in its attacks, not having been found in Ohio fields earlier than August 3rd. It causes angular, yellowish spots in the leaves, followed by yellowing of the whole leaf and death, as by frost. It spreads with extraordinary rapidity, requiring only three or four days to become disseminated throughout a large field. Unlike anthracnose, it may not be successfully checked after its appearance, and it is not safe to leave untreated plots in fields to be sprayed. July 25th to August 1st is sufficiently early to begin spraying for mildew, but applications should be repeated at intervals of 7 to 9 days. In 1898 an increase of 75 bushels per acre, of sprayed over unsprayed cucumbers, was obtained at Creston. (Bulletin 105). Cucumber pickle growing finds in this mildew its most serious enemy. If any of the crop is to be harvested after August 20-25 spraying with

Figure 24. Cucumber leaf with Downy Mildew. Lighter areas are yellow in leaf.

[57] *Plasmopara Cubensis* (B. & C.) Humph.

fungicides appears necessary. Early planting may permit gathering the crop before this date. The downy mildew is also very destructive in the forcing-house, and is to be treated with the same fungicides recommended for anthracnose. (Bulletins 73, 89 and 105).

Powdery Mildew[58] of cucumbers is also frequent in the forcing-house, but rarely destructive elsewhere. For this fungus a dilute copper sulfate solution is effective. (See Bulletin 73).

Leaf-spot of cucumber is also due to fungi.[59] Of the two species named, the Phyllosticta was the commoner in thrifty pickle fields in 1898; the Cercospora being apparently confined to wet fields, though this cannot be expected to hold true under all circumstances. The Phyllosticta was found almost exclusively upon the unsprayed pickle plants and seems, therefore, amenable to the same treatment as applied for downy mildew. (Bulletin 105).

Spot of Cucumber Fruit or **Cucumber Scab,**[60] has been reported upon cucumbers by Dr. Arthur, (Ind. Exp. St. B. 19) and may prove injurious if prevalent. It should be found amenable to the same treatment recommended for anthracnose and downy mildew.

Cucumber Wilt: — The wilt disease of cucumbers, likewise of other cucurbits, is a source of usual complaint in the earlier season, as the plants are beginning to form vines. In 1899 these complaints continued much later. The plants suddenly wilt down as from lack of water, then soon die. What has been referred to the same general cause was also observed in the cucumber forcing-house, apparently starting in the leaves. Smith (Proc. Am. Ass. Adv. Sci. 1893) refers this disease to a bacterium[61] which is transferred from diseased to healthy plants by the cucumber beetle and the squash bug. This form of wilt has been found on cucumbers, muskmelons and squashes in Ohio. In addition we have found, to a limited extent, another wilt disease of the cucumber which appears to be similar to that described by Dr. Smith. (Proc. A. Ass. Ad. Sci. 1895, page 190). On watermelon in the South he finds a trouble with which ours may be identical. (Bulletin 105, page 222). This latter is referable to a species of fungus, a fusarium,[62] which grows internally in the stem and finally plugs up the water vessels in a manner similar to the work of the bacterial wilt. Spraying is unlikely to be beneficial for this wilt or for the bacterial one. Preventive measures suggest gathering and burning infected vines, and especially waging a successful war against the insects; these should prove more or less successful according to

[58] *Erysiphe Cichoracearum* DC.

[59] *Phyllosticta Cucurbitacearum* Sacc. and *Cercospora Cucurbitae* E. & E.

[60] *Cladosporium cucumerium* Ell. & Arth.

[61] *Bacillus tracheiphilus* Smith.

[62] *Fusarium niveum* Smith.

thoroughness secured. The last named wilt disease will call for rotation of crops.

Nematodes or Eelworms:[63] — These minute parasitic worms are often very destructive upon cucumbers under glass. They are especially so in some cases recorded in Bulletin 73. The greatest injury may occur on the seedling plants, but plants of all ages are destroyed by the parasitic worms. Their presence may be known by the small, bead-like enlargements produced upon the roots or rootlets. This matter is treated at some length in that Bulletin. No remedy has been discovered that is effective with plants once attacked by eelworms. The time to prevent this trouble is in the selection and preparation or treatment of the soil for greenhouse benches. Indeed the nematodes seem to be present in old sod, and to some extent in decaying vegetable matter generally. An effective remedy against eelworms consists in steaming and so treating the soil that the parasites will be destroyed. For this procedure see calendar and Bulletin 73. Also Massachusetts Exp. Sta. Bul. 55. In thus handling the soil due time must be given for draining and drying.

Figure 25. Roots of seedling cucumber with Nematode Galls.

CURRANT.

Dropsy: — This disease has been met with. It causes very considerable enlargement upon the young stems of the currants, not unlike in appearance the enlargements due to crown gall in the peach, except that usually more of the stem is involved than in the other case. The trouble appears to be due to physiological causes and the pruning knife may aid cultural efforts.

Leaf-spot of currants is referable to two species of fungi,[64] of which only the Septoria has been discovered in Ohio. (See Bulletin 79). These fungi produce early spotting and premature dropping of the currant foliage; in some instances the leaves drop even before the fruit has ripened. Bordeaux mixture applied as per calendar is effective against this disease, though late applications may render it necessary to wash the fruit. For this reason, if for no other, the first application should be made very early and followed by about two more at fortnightly intervals.

Mildew: — This trouble is identical with the mildew of the gooseberry, which is successfully prevented by spraying with Bordeaux

[63] *Heterodera radicicola* (Greef.) Mull.

[64] *Septoria ribis* Desm., *Cercospora angulata* Wint.

mixture of potassium sulfid. In at least one instance the mildew spread from the Industry foliage to a large area of young currants.

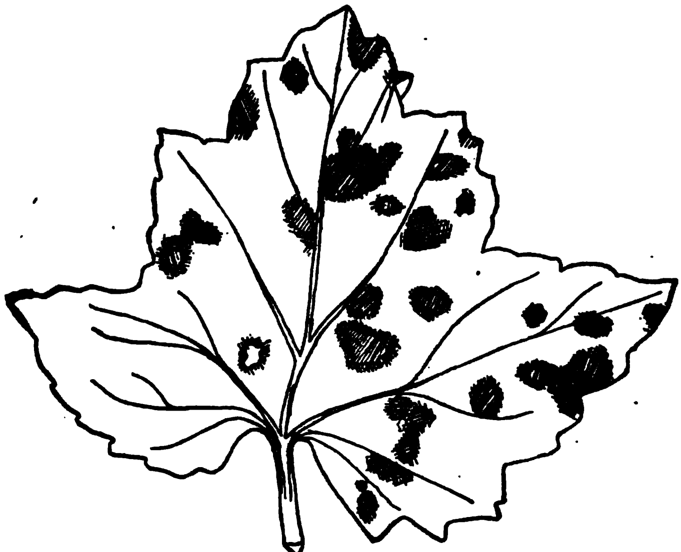

Figure 28. Leaf-spot disease of Currant.

DEWBERRY.

Leaf-spot:[65] — Cultivated dewberries as well as the wild sorts, are peculiarly susceptible to the attacks of the leaf-spot fungus. It causes very small grayish spots in the leaves. The same fungus attacks blackberries and raspberries, as previously stated. It may be prevented by a careful application of Bordeaux mixture.

Rust: — The bramble rust also attacks the dewberry as in the case of blackberry. For treatment see blackberry.

EGG-PLANT.

Dr. Halsted and Dr. Smith have reported (Rep. N. J. Exp. Sta. 1890-91-92; Bulletin 12, Div. Veg. Phys. and Path. U. S. Dept. Agr.) several diseases upon egg-plant, including anthracnose, bacterial blight, leaf-spot, seedling rot and stem rot. These do not seem to require extended discussion in this place.

ELM.

Leaf Disease and Mildew:[66] — The leaves of ornamental elms are sometimes attacked by a fungus which produces small, circular dead spots. This fungus matures its spores in the fallen leaves and may be somewhat checked by gathering and burning them. Elm leaves

[65] *Septoria rubi* West.

[66] *Gnomonia Ulmea* Thüm.

are also attacked by the powdery mildew.[67] This, if disfiguring, may possibly be reached by Bordeaux mixture, making the first application when the leaves are about half grown.

FLAX.

Dodder: — Flax is attacked at times by a seedling parasite, flax-dodder,[68] whose tiny, leafless stems wind about the flax plant and by haustoria, or sucking organs penetrating the epidermis, draw from it substances essential to healthy growth. The dodder seeds are carried in the flax seed and prevention must seek to avoid the seeds.

GOOSEBERRY.

Leaf-spot: — The gooseberry leaves are attacked by the same leaf-spot fungus recorded upon the currant,[69] although the defoliation may be even more severe than on the currant. In spraying experiments at this Station, conducted by the Horticulturist, it has been found that the gooseberry leaf-spot is even more easily prevented than the currant leaf-spot. Indeed no fungous disease upon which we have experimented is more easily prevented when the fungicide is applied at the proper time. (See Spray Calendar). Often the leaves from gooseberry plants have all dropped before maturity of fruit, and in hot weather all the fruit has been lost on the unsprayed, check plants, while the sprayed plants gave a fine yield of satisfactory fruit.

Mildew[70] is a destructive fungous disease especially common upon English varieties, such as Industry, Crown Bob, etc. It has been destructive also upon the Houghton. As already stated this mildew attacks currants. From the nature of this fungus the first spraying with Bordeaux mixture should be made early in the season. (See Bulletin 79). Subsequent applications may be either of Bordeaux mixture or potassium sulfid. (See calendar). After fruit is half grown the latter fungicide is to be preferred since it is more easily removed from the fruit.

GOURD.

Anthracnose, Downy Mildew, etc.: — Gourds are susceptible to the same fungous diseases as the cucumber. The two most conspicuous are anthracnose and downy mildew. The anthracnose, especially, causes spotting and discoloration on the gourds. This may be arrested if, when the gourds are gathered, they are subjected to treatment with scalding water; otherwise the development of the fungus continues while the disfiguring increases. Field treatment in this case is the same as recommended for like diseases of the cucumber.

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[67] *Uncinula macrospora* Pk.

[68] *Cuscuta Epilinum* Weihe.

[69] *Septoria ribis* Desm.

[70] *Sphaerotheca mors-uvae* (Schw.) B. & C.

Figure 27. Grapes attacked by Anthracnose, also called Birds-Eye Rot.

GRAPE.

Anthracnose:— As is well known we have a long list of fungi attacking the grape, among them the anthracnose fungus[71] which is found upon leaves and stems as well as the fruit, causing definite sunken spots, usually with a central area of lighter color. Upon the fruit the appearance has suggested the name "bird's-eye-rot." Where prevalent the anthracnose may be entirely prevented by following the directions in the use of Bordeaux mixture as given in the calendar.

Bitter Rot[72] of the grape is sometimes prevalent but perhaps less frequent in Ohio than the black rot.

Black Rot[73] is one of the most troublesome and destructive of grape diseases. It chiefly attacks the fruit and causes dark

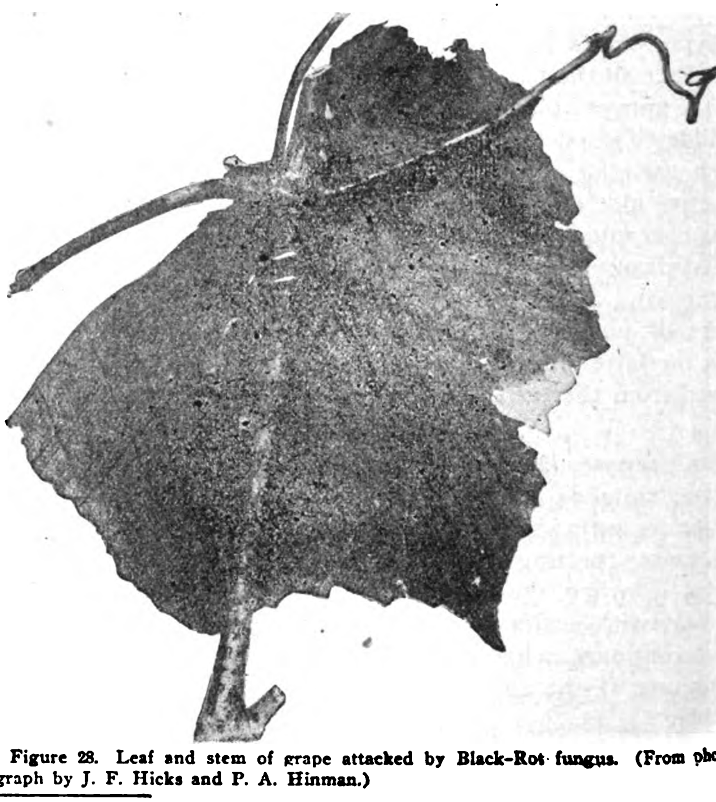

Figure 28. Leaf and stem of grape attacked by Black-Rot fungus. (From photograph by J. F. Hicks and P. A. Hinman.)

[71] *Sphaceloma ampelinum* D'By.

[72] *Melanconium fuligineum* (Scrib. & Viala) Cav.

[73] *Laestadia Bidwellii* (Ell.) Viala & Ravaz.

spotting and rotting of the green berries, but it may also attack the leaves, petioles and cluster branches, producing circular or elongated dead spots in them. The rotted fruits persist upon the branches and may hang on over winter, thus carrying the fungus from year to year. This disease, if neglected, is very destructive and the longer the neglect the greater is the difficulty in prevention. Bcause of the circumstance stated, delay in beginning the treatment increases the difficulty. It is apparently essential that first applications of fungicide for the black rot be made while the vines are dormant and that these be very thorough, followed by the later applications as per calendar. Omission of the spraying just before the blossoms open may lead to ragged clusters, from dropping of the small grapes. (See Report of the U. S. Dept. of Agr. 1896.)

White Rot,[74] or a disease thought to be this, prevails now in northeastern Ohio vineyards. It has been very destructive in portions of Ashtabula, Lake, Cuyahoga and Lorain counties for the past three seasons, being usually associated with black rot. It is characterized by late development, more especially in later July and during August. First a light colored spot, then the whole grape hangs rotted and of the same light brown color, with fungus pustules of darker brown, subsequently mealy white in the dried grape. The period when the grapes begin to assume a ripened color is one of great danger. It seems that this same rot prevailed in 1872 and was locally called "Greeley Rot." The treatment is about that for black rot with perhaps more emphasis on the later applications of Bordeaux mixture and ammoniacal copper carbonate.

Figure 29. A cluster of grapes attacked by White Rot.

Downy Mildew[75] of the grape is a prevalent fungous disease which has long been known and repeatedly studied. By it the leaves are attacked and the fungus forms in them öospores by which the winter is passed. The fungus also attacks the berries, causing brown rot. Gathering and burning the fallen leaves may therefore be useful. No particular difficulty attends the prevention of downy mildew if spraying is thoroughly done.

Powdery Mildew[76] is likewise prevalent upon both leaves and fruit. Like all powdery mildews the parts attacked are covered over by the web-like threads of the mildew fungus. This is successfully

[74] *Coniothyrium Diplodiella* (Speg.) Sacc.
[75] *Plasmopara viticola* (B. & C.) Ber. & D'Ton.
[76] *Uncinula necator* Schw.

prevented by the use of Bordeaux mixture as elsewhere directed. (For illustrations of grape diseases see Report U. S. Dept. of Agriculture 1886 and 1887; also Scribner, "Fungus Diseases of the Grape, etc.")

Grape Canker or Winter Injury has been frequently referred to us. Owing to injury caused by freezing, dead spots are produced in the vine, which in the process of healing become surrounded by excessive growth and enlargement. In some instances the enlargements attain a diameter two or three times that of the stem. Care in the matter of drainage and judicious pruning seem to be useful against this trouble.

Crown Gall of the grape, in which considerable enlargements are formed near the surface of the crown similar to the excrescences upon fruit trees, is a common trouble of the Pacific slope and doubtless occurs in Ohio. Removing and burning the affected vines is recommended.

GRASSES.

Smut and **Rust** are found upon most species of grasses. These are in part described under blue-grass, timothy, etc.

HOLLYHOCK.

Anthracnose:[77] — An illustration has been published in the Journal of Mycology (Vol. 6, 46-48).

Leaf Blight[78] is another fungous disease of the hollyhock. These two diseases of the hollyhock should be amenable to spraying with standard fungicides.

Rust:[79] — On the other hand this recently introduced disease of the hollyhock is much less likely to be prevented by spraying. The rust fungus forms dense patches, spots or sori, on the under side of the leaves. These are commonly about one-sixteenth inch in diameter or more, of grayish-brown color and projecting below the leaf surface, while a minute yellow spot early appears on the upper surface of the leaf. Subsequently the diseased leaves drop and by the time the plants are blooming the stem below is bare or disfigured by the remains of the diseased leaves. At the Station this rust has been prevalent and the complaint is general respecting the same trouble. It would seem wise to gather and burn all the affected leaves and likewise the old stems as early as possible. Between anthracnose and rust these popular old flowers are having, at present, a difficult time of it.

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[77] *Colletotrichum malvarum* (Braun & Casp.) Southw.

[78] *Cercospora Althaeina* Sacc.

[79] *Puccinia Malvacearum* Mont.

HORSE-CHESTNUT.

Leaf-spot:[80] — This popular shade tree is attacked by the leaf-spot fungus which causes spotting and dying of the leaves, with subsequent dropping from the tree. This seriously disfigures the tree and must impair its vigor. The disease may be checked, or altogether prevented by the proper use of Bordeaux mixture. Results of experiments are reported in the Journal of Mycology (Vol. VII, page 53). The first application should be made when the leaves are about half grown, with repetition at intervals of about three weeks.

HORSERADISH.

Leaf Blight and **Leaf-spot Fungi,** Ramularia and Septoria respectively, sometimes attack the leaves of horseradish. The same is true of **white mold**[81] which is so generally prevalent on mustard weeds. The injuries are not usually important and certainly, in no case observed by the writer, has there been any serious check to the horseradish when growing as a weed.

LETTUCE.

Anthracnose or **Leaf Perforation:**[82] — This disease of greenhouse lettuce was described in Bulletin 73. It has since been reported in some other localities. In well regulated greenhouses the disease is unlikely to prove serious, although disfiguring.

Downy Mildew[83] is the work of another fungus which belongs to the same class as the downy mildew of the cucumber. It forms yellow spots in the upper leaf surface which appear below as whitened, downy covered areas. Like the downy mildew of cucumbers this one may spread very rapidly under favorable conditions, such as warmth and surface watering in the greenhouse. Keeping water from the foliage by sub-irrigation of the beds has been found very beneficial (Bulletin 73). Gathering and burning the diseased leaves or plants will usually repay the labor. Particular attention to heat and moisture will usually render spraying unnecessary and it is certainly inadvisable except to eliminate the fungus from the house. Avoid too high temperature or too much moisture on plants.

Lettuce Rot or **Lettuce Drop:** — This is by all odds the most troublesome disease to the lettuce grower. The plants may rot off at the surface of the earth and the central parts, especially of head lettuce, may become attacked by the rot fungus.[84] The fungus appears as a whitened covering with a liberal production of spores in

[80] *Phyllosticta sphaeropsoidea* E. & E.
[81] *Cystopus candidus* (P.) Lév.
[82] *Marsonia perforans* E. & E.
[83] *Bremia Lactucae* Regel.
[84] *Botrytis vulgaris* Fr.

clusters. At this Station it has not been possible to succeed with the head lettuce because of the rot. Fumigation of house, the use of fresh or steamed earth each year and the careful regulation of temperature and water supply, seem to be the measures most favorable to prevention. A low night temperature, less than 50 degrees F. is very desirable, while too high a temperature will usually result in disease. Ventilation is all essential during the day. It is desirable also to gather and burn rotted leaves and plants.

MAPLE.

Anthracnose:[85] — This disease attacks young Norway maples (See N. Y. Sta. Report '95) and has been also identified on the young shoots of sugar maples in Ohio. The new leaves were reported destroyed by the fungus. Applications of Bordeaux mixture should check this disease.

Rhytisma and **Leaf-spot:** — The leaves of cultivated maples are often disfigured by dark colored incrustations following the line of the veins. These incrustations are almost black and are caused by a fungus.[86] The trouble is usually not serious, but if prevalent it would seem advisable to gather and burn all leaves attacked by it. The leaf-spot fungus[87] often causes small spots, or dead areas, in the leaves. This may sometimes prove so serious as to call for applications of fungicides.

MILLET.

Leaf-spot: — Leaves of millet, dying from small, light-colored spots, were recently examined. These spots are due to a fungus[88] and the dying may at times be enough to shorten the yield of forage.

Smut: — The seeds of millet are often attacked by the millet smut fungus[89] which transforms them into black masses of smut spores. much after the manner of stinking smut in wheat. This is liable to injure the feeding value of the millet, although it is not likely that the smut will injure stock when millet is fed in the usual quantities. All smutted grain, of course, is ineffective and useless and the smutted seed when again sown will produce a smutted crop. The smut is prevented by the same hot water seed treatment as that applied to prevent oat smut. In experiments conducted by the Botanist of this Station this treatment was successful.

MUSKMELON.

Downy Mildew of muskmelon is caused by the same Plasmopara fungus as the downy mildew of cucumbers. As we have the fungus

[85] *Gloeosporium apocryptum* E. & E.
[86] *Ryhtisma acerinum* (Pers.) Fr.
[87] *Phyllosticta acericola* (Cke. & Ell.)
[88] *Piricularia grisea* (Cke.) Sacc.
[89] *Ustilago Crameri* Kornicke.

in Ohio it does not appear until towards the middle of August, but is then very destructive, sweeping rapidly over the melon fields and leaving only devastation behind. In its attacks the spots of the muskmelon leaves are somewhat different in shape and usually of a darker color than in the case of the cucumber. One with experience can readily distingush by the use of an ordinary hand-glass. He will then see on the under side of the leaf the violet spores and spore-bearing threads of the mildew fungus. The melons which are unripened upon the vines when attacked by mildew are practically worthless and for this reason large losses are usually incurred. The treatment is by Bordeaux mixture, as for cucumbers.

Muskmelon Leaf Blight is a disease more or less peculiar to the muskmelon, although the fungus[90] which causes it has also been found upon cucumber leaves. The leaf blight causes rather large dead areas in the leaves which are usually distinguished from those of downy mildew by their larger size and the tendency of the central portion to break out. The prevention of muskmelon leaf blight is by no means an easy matter, requiring of itself great thoroughness and carefulness in the application of the Bordeaux mixture and also requiring that the downy mildew shall be watched during the same period. For this reason earlier sprayings, if made before August 1st, should be repeated at fortnightly intervals, while those after August 1st should be at weekly or ten-day intervals. Melon growers have succeeded by following these lines, while others who were less thorough were less successful, or failed entirely. The treatment is recommended with confidence. (Bulletins 73 and 105).

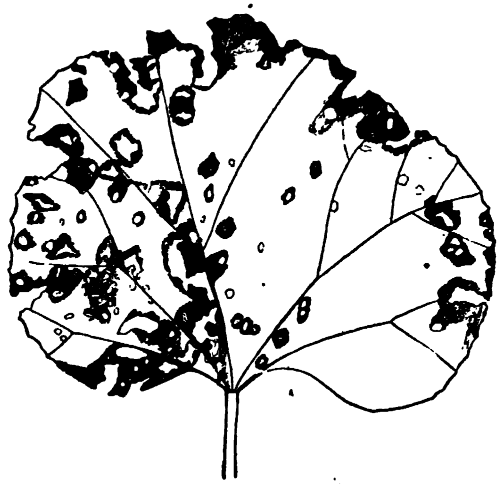

Figure 30. Alternaria Leaf Blight of muskmelon leaf.

Muskmelon Wilt is the same in general character as that described for the cucumber. Not only the bacterial wilt disease but the wilt due to fusarium has developed upon muskmelons in this state. The symptoms are the same as for cucumbers, namely: sudden wilting as from lack of water, followed by dying. The preventive treatment is the same as before recommended.

[90] *Alternaria sp.*

MUSTARD.

Club-root: — Mustard plants generally are attacked by the club-root fungus[91] when this is present in the soil. For this reason the weeds of several species may be infested upon lands that have never

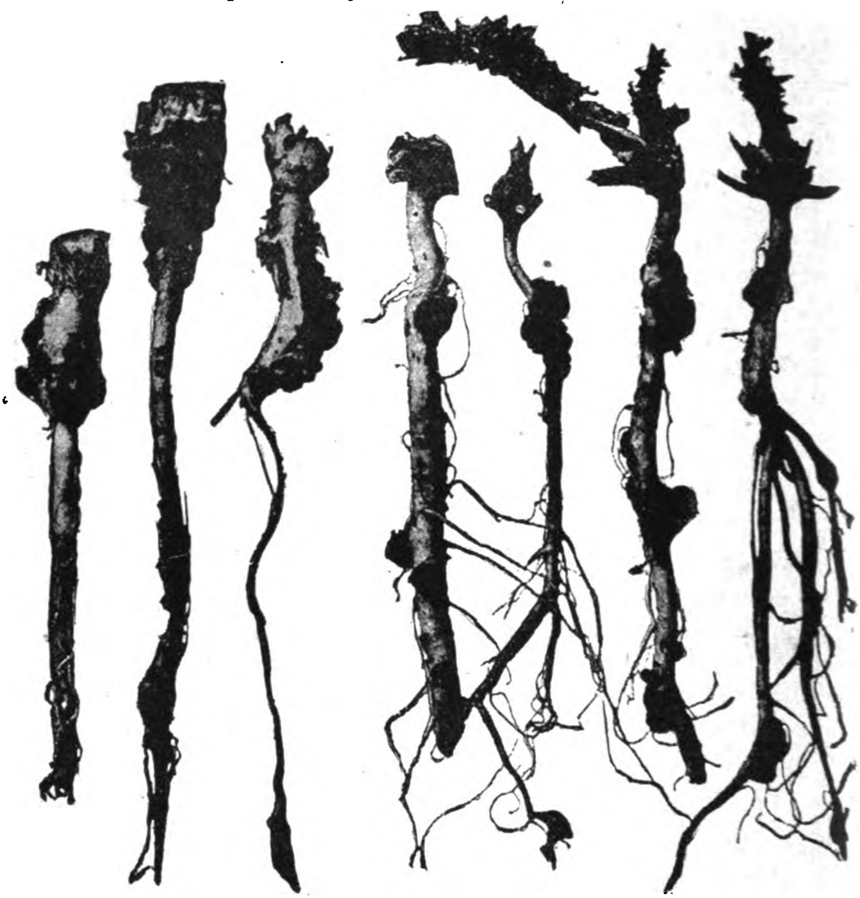

Figure 31. Roots of shepherd's purse attacked by Club-Root.

Figure 32. Roots of hedge mustard with Club-Root (Both after Halsted, Bul. 98, N. J. Exp. Station.)

been brought under cultivation. Due attention should be given to mustard plants in new lands when designed for cabbage.

OATS.

Bacterial Disease of oats has been at times destructive. It causes dying of the lower leaves and more or less yellowing of the young plants. (See Journal Mycology Vol. VI, page 72). It has been observed on oats at this Station but as yet no effective remedy has been discovered.

[91] *Plasmodiophora Brassicae* Wor.

Rust: — In addition to the two species of rust found upon wheat, and to be given under that grain, there is a rust common upon oats,[92] usually prevalent during the rainy harvest weather and more or less at all times. No remedy is as yet at hand.

Figure 83. Panicle of oats destroyed by Loose Smut.

Smut: — The smut of oats takes on two forms, the loose smut[93] and the hidden smut.[94] The first, which is the more common, converts the entire head, including glumes, into a sooty mass of smut spores; while in the hidden smut the enclosing glumes remain about the smutted grain. No other essential difference has been found between them. Both are caused by spores from smutted seed, or seed from smutted grain, and both are successfully prevented by seed treatment with hot water or formalin as per scheme given elsewhere. (See calendar and also Bulletins 64 and 97). An increase of yield beyond smut prevention has usually followed seed treatment. This alone pays for the cost of treatment and the saving from smut loss is clear profit.

OAT-GRASS.

Smut: — There has been at the Station a smut on tall oat-grass[95] which closely resembles loose smut of oats but is, in fact a separate species of smut whose mycelium survives in the rootstocks of the oat-grass.[96] The smut is thus continued in the same plants from year to year. It is not clear whether the smut would be transmitted in new seed, but there is some danger, at least.

ONION.

Blight: — Blight of onions during mid-season, when the weather is warm and dry, is rather a common occurrence. This was especially noticeable during 1898 and 1899. While often attributable to insects, species of fungi, especially molds,[97] were abundant in the seasons named. It may be possible to check these molds by spraying.

Downy Mildew[98] is likely to occur upon onions, although it has not been seen in Ohio by the writer. The treatment would be as for downy mildews of other plants.

[92] *Puccinia coronata* Corda.
[93] *Ustilago Avenae* Jens.
[94] *Ustilago Avenae laevis* (Jens.) Kell & Swing.
[95] *Arrhenatherum elatius* L.
[96] *Ustilago perennans* Rostrup.
[97] *Macrosporium Sarcinula parasiticum* (B.) Thüm — *M. Porri* Ell.
[98] *Peronospora Schleideniana* D'By.

Onion Smut, on the other hand, is prevalent to a considerable extent in Ohio, and is one of the most destructive of the smut fungi known to pathologists. This onion smut,[99] unlike the other smuts with which we have to do, propagates itself almost indefinitely in the soil when this once becomes infested. Whenever a new crop of onions is grown from seed in this infested soil the smut attacks the young seedling onions, in whole or in part, and a very considerable loss results therefrom. If however onion sets are put in such soil, or seedling onions that have been started under glass in healthy soil are transplanted to smut infected soil, the smut fungus cannot attack them. The explanation seems to be that the smut threads are only able to penetrate the leaves of the young, tender seedlings. This onion smut is now known to occur in fields at Berea and near Chillicothe. At the latter place it has seriously embarrassed some of the growers of onions for sets; for this work transplanting is, of course, out of the question. In Connecticut Experiment Station Report for 1889, it is stated that flowers of sulfur have been used to sow with the seed in infested soil, and this remedy has given but slightly inferior results to any other yet tried at this Station. Forty percent formaldehyde, known commercially also as formalin, has given better results than sulfur in 1900.

Figure 34. Smutted and sound onion seedlings. (From a photograph by P. A. Hinman.

PEA.

Blight, Leaf-spot, Sun Scald: — Young peas are frequently blighted and have the leaves spotted by fungi referable to the genera Ascochyta and Septoria.[100] These troubles have been described by Dr. Halsted (N. J. Exp. Sta. Rept. 1893). As yet they have not proved very troublesome in Ohio.

Powdery Mildew:[101] — The mildew fungus often attacks the pea and at times entirely destroys its fruitfulness. It may be known by the whitish coating produced upon the leaves and by the dark, pin-head spots of the fungus observed to be situated in these white cover-

[99] *Urocystis Cepulae* Frost.
[100] *Ascochyta Pisi* Lib. & *Septoria Pisi* West.
[101] *Erysiphe communis* Wallr.

ings. The same fungus likewise attacks the bean. For either plant spraying with Bordeaux mixture, as per directions in calendar, will be found beneficial. The first application should be made promptly.

PEACH.

Crown Gall:—This is a very contagious disease of the peach and of other fruits, notably raspberry, blackberry and pear. Sometimes it produces excrescences and enlargements upon the root and stem of the affected plant. More commonly the galls are found upon the stem just below the surface of the earth. These vary in size and in location, even occurring upon the small roots, and less frequently upon the stem at some distance above the ground. In some recent experiments (Bulletin 104) it was found that the gall trouble became communicated from diseased raspberries to peach trees set in the plantation. In some instances the losses from crown gall have been large and there is, in my judgment, no other disease common to several of our fruit trees that is so threatening in its ravages. The peach trees attacked in most cases perish without producing fruit. This applies when the trees are affected at nursery age — the usual condition. Purchasers cannot afford to set such diseased trees nor nurserymen to ship them. As yet the only treatment we can recommend is to dig out and burn the diseased trees, and to avoid planting affected stock. Indeed no affected stock should be received. This, with other diseases of the peach, has been treated in Bulletins 92 and 104.

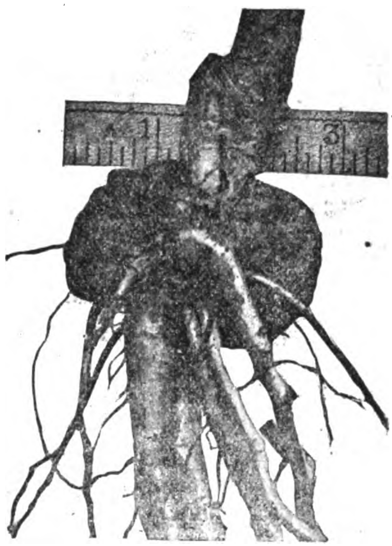

Figure 35. Root of nursery peach tree attacked by Crown Gall.

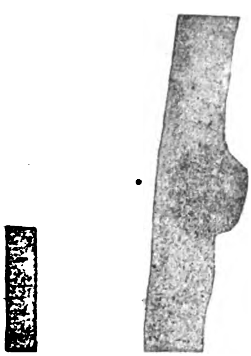

Figure 36. Crown Gall attacking stem of peach tree.

June Drop is often named by peach growers as a specific trouble. It consists in the dropping of the young peaches during the month of June, though dropping sometimes comes earlier. The cause appears to be physiological and need not to be feared where trees have been prevented from overbearing, or protected from the effects of drought by thorough cultivation the previous season.

Little Peach is a disease much discussed in Michigan and quite serious in the fact that the peaches on diseased trees never come to

proper maturity or develop marketable character. Dr. Smith has found that the root hairs on many such trees are not healthy and thus it appears that some specific trouble is located there.

Leaf-curl:[102] — The leaf-curl fungus is at times one of the serious pests of the peach grower. However, destructive leaf-curl does not occur every year. The curl fungus survives as mycelium in the buds from year to year. It is therefore present each season, though possibly in varying amount. We have found in Ohio that serious leaf-curl comes when cool weather, with frequent rains, prevails during April, May and June. It is to the April weather that the most serious results seem attributable. With low temperature and frequent rains during the early half of this month we may safely predict an outbreak of leaf-curl. (Bulletin 92). During such weather the fungus develops rapidly and the new leaves are affected as they are protruded from the bud. In a modified sense the same takes place during May and in a still more limited way during June. Successful prevention of leaf-curl is secured by thorough early treatment with Bordeaux mixture. Indeed, it appears that a spraying at any time shortly before the blossoms open is several times more effective than any application afterward. It appears that more effective results are secured by spraying two weeks before blossoming than immediately before the blossoms open. In any event an application made just before the blossoms open is much more effective than at any later date. Whale-oil soap has also proved effective applied at this time, though not safe at much earlier dates. It is more expensive than Bordeaux mixture. (See Bulletins 92 and 104).

Figure 87. Effects of Leaf-Curl on peach. (After Atkinson. Bul. 73 Cornell Expt. Station, reduced.)

Leaf-Spots of the peach may be due to a variety of causes and in no cases studied have they proved destructive. These are illustrated and very briefly discussed in Bulletin 92.

Pustular Spot of the peach is a disease referable to a minute fungus[103] which is apparently spread by spores that alight upon the upper surface of the fruit, flourish there and produce minute, light-brown spots, often surrounded by an angry, red border. The red border is conspicuous in earlier varieties and is sometimes elevated and pustular in appearance. This fungus greatly disfigures the fruit and is very easily prevented. Three applications of Bordeaux mixture have reduced the amount of pustular spot to less than one percent; whereas unsprayed trees gave more than 16 percent of spotted fruit, much of which was seriously damaged. (Bulletin 92).

[102] *Exoascus deformans* B. [103] *Helminthosporium carpophilum* Lév.

Rot, or Brown Rot: — The brown rot fungus[104] is among the most destructive of the fungi on the peach, yielding place only at times to leaf-curl. Unlike leaf-curl the brown rot prevails during warm, showery weather, and with such a weather period is likely to occur at any time of the year. In April, if the mummy peaches are permitted to remain on the trees from the preceding year, the fungus may affect the twigs through the blossoms and thus cause serious twig blight. It is a matter of common remark that the branches upon which rotted peaches are found often perish from the effects of the rot fungus. No one variety seems more susceptible to rot than others, although some sorts are more liable to ripen during rainy weather and then rot worse. The control of rot demands: First, careful removal and destruction of all mummy rotted peaches; Second, thorough spraying of the trees before blossoming, as for leaf-curl; Third, subsequent spray treatment as per calendar, may be profitable under certain conditions.

Figure 38. Rotted and dried, or "mummy" peaches on tree in spring.

Root Rot: — In some instances, notably at Gypsum, Ohio, where peach trees were planted in a dense, clay soil, the roots often decay, apparently from the attacks of some fungus. Trees thus attacked usually perish soon. Whether the trouble is primarily due to the fungus or to the location in which the trees are grown has not been determined.

Scab: — The scab fungus[105] is prevalent during rainy seasons particularly upon susceptible varieties, such as the Morris's White, Salway, Heath, etc. It causes dark spots upon the fruit. As brought out in experiments published in an earlier bulletin (No. 92) spraying with Bordeaux mixture may greatly reduce the proportion of affected peaches, and if continued may check the scab. As was stated for leaf-curl, an early application is essential.

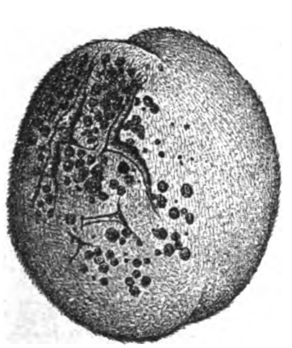

Figure 39. Peach attacked by scab. (After Smith, Farmers' Bul. 17, U. S. Dept. Agric.)

Twig Disease with Gum-Flow sometimes referred to as gummosis is, like crown gall, a trouble of recent development in Ohio. In it we find small, diseased or dead spots on the twigs, usually near the buds, and there is ordinarily a copious flow of

[104] *Monilia fructigena* Pers.

[105] *Cladosporium carpophilum* Thüm.

gum from these spots. The trunk may likewise be affected, though less commonly, unless the bark beetle has punctured the trunk. In large orchards it would be wise to dig out and burn the earlier cases of gum-flow, and in general, treatment of the trees with fungicides should prove useful.

Winter Injury: — In our climate the severe freezing of winter often injures the trunk and branches of peach trees. The common

Figure 40. Peach Yellows; winter buds of diseased tree unfolding in autumn. (After Smith, Farmers' Bul. 17, U. S. Dept. Agric.)

killing back of new growth by freezing is a familiar phenomenon. The less common killing of the trunk on one side, usually the west or southwest, is less known. Many instances have been studied. Wherever there has been late growth of the trees, followed by severe winter cold, such injury may be expected. Late cultivation is therefore to be avoided. Winter injury to fruit trees may be attributed to the drying out of the trees and it is worth while to consider whether by mulching, or soil conditions, the tree may not be made to have at command an abundant supply of available moisture when the

upper soil is frozen hard. Much injury to peach trees from freezing occurred during February, 1899. In the larger proportion of these cases there was more water in the soil, or about the trees, than in the less injured localities. More exposed situations also gave more injured trees.

Yellows: — Peach yellows is a serious, contagious disease of this fruit in most portions of Ohio. Only in certain seasons may we find yellowish color as a marked symptom of affected trees. The true symptoms of yellows are: — 1. Premature ripening of the fruit which is highly colored, often purplish spotted, and has the flesh marbled with red. 2. The premature growth of winter buds, resulting in excessive branching on new shoots, and the development of slender, wiry-branched twigs. 3. Resting buds, or adventitious buds are formed on the trunk and branches; these grow into sickly shoots with pale, narrowed leaves, and usually become much branched, with tips like veritable brooms. Aside from these specific evidences of yellows which serve to distinguish yellow color from true yellows disease, there are others less easily described but none the less useful to the practical observer. This disease may be recognized late in the season by the late, adventitious growth. The sources of disease are diseased trees or affected nursery stock, more often the former. The remedy is to remove and to burn the yellows trees, root and branch, on the spot where found. Dragging diseased branches may spread yellows and all such trees are a menace. To leave an open hole over winter and replant the next year is a safe practice. (See Bulletins 73 and 92 for fuller discussion).

PEAR.

Pear Blight or **Fire Blight** is one of the most serious drawbacks of pear growing. The symptoms of dead twigs and branches are well known. In substance our knowledge of pear blight is about this: — It is due to a bacterium[106] which, in the old cases of blight, winters over in the blighted parts. With April and May showers there is some exudation of watery substance from these parts, which is visited by insects and by them transmitted to the opening blossoms. The microbe there breeds in the nectar of the blossom and in that manner attacks the branches; once within the tissues the microbe may spread indefinitely. Some varieties of pears are more susceptible, apparently, than others, which simply means that in them the microbes spread more rapidly. There is not a single blight-free variety of pear in our region. The remedy consists in cutting off and burning the blighted parts each autumn, extending the work to the crab-apple, apple, and indeed to every variety of pome fruit which is attacked by this bacterium. (Bulletin 79. Year-book U. S. Dept. of Agric. 1895).

[106] *Bacillus amylovorus* (Burr.)

Crown Gall: — The crown gall attacks the pear both at the crown and upon tips of roots. It is less rapid in its destructive effects here than upon the peach, though but slightly less serious. Enlargements may be readily detected and they are usually of denser, more woody growth than upon the peach. The same remedies apply here as with that fruit.

Figure 41. Crown Gall on end of pear root.

Leaf Blight of the pear is produced by the leaf blight fungus[107] which causes spotting and dying of the leaves, also cracking of fruit. The diseased leaves show a dense, dark colored coating on the under side. This disease is readily and successfully prevented by the use of Bordeaux mixture.

Leaf-spot of pear is another fungous disease which may flourish despite the use of Bordeaux mixture, as generally applied. This fungus[108] appears not to yield to the standard fungicides. It produces small, circular dead spots in the leaves; the spots in later summer may drop out, leaving holes. It is quite prevalent, but as yet no specific recommendations can be made for it.

Pear Scab is a fungous disease allied to Apple Scab; the pear scab fungus[109] being very similar in development to that of apple scab. This fungus was very abundant in 1898. It may cause spotting of the leaves or spotting of the fruit of the pear but is not readily distinguished from the other troubles, save by the use of the microscope. It is prevented by the use of Bordeaux mixture.

Sun Scald or **Trunk Blight** often shows itself in dead patches upon the trunks of pear trees. It is frequently a serious trouble, and is thought at present to be referable to the localized attacks of the pear blight bacterium. The removal of rough bark and the maintenance of smooth condition of the trunks of trees, together with the possible application of a whitewash of strong Bordeaux mixture, are suggested for this trouble.

PLUM.

Black-Knot: — This is the same disease as that described under black-knot of cherry. It is more frequent upon the Damson than upon the other European plums, but requires only the removal and burning of the knots each year before March, in order to grow plums successfully and without serious injury from this disease.

Crown Gall is occasionally found on the plum and is similar to that appearing upon peach and pear.

[107] *Entomosporium maculatum* Lév.
[108] *Septoria piricola* Sacc.
[109] *Fusicladium pirinum* (Lib.) Fukl.

Plum Rot is by all odds the most serious disease with which Ohio plum growers have to deal, outranking by far black-knot, shot-hole fungus and all the other ills plums are heir to. It is the same in character as the rot of other stone fruits. As with the peach, the rot fungus[110] lives over winter in the mummy rotted plums of the year before and possibly, to a limited extent, in affected branches. The first step in successful control of rot is the removal and burning of these old plums. The next step is to spray thoroughly, before the buds open, and to continue the spraying and picking the rotted plums as circumstances demand. Likewise, control the curculio. For details of treatment see calendar. No halfway measures will yield satisfactory results in dealing with plum rot.

Figure 42. A cluster of plums destroyed by Brown Rot.

Shot-Hole Fungus is at times a very destructive disease of the plum. It is due to the same fungus[111] which attacks the cherry, although in this case even more serious injury is liable to result than with cherry trees. Where trees are defoliated by shot-hole fungus the fruit is of small value and the trees put forth new foliage and blossoms, thus leaving immature wood and a sappy condition for trouble in winter. Under such circumstances the secondary losses may be enormous. This fungus is readily prevented by spraying with standard Bordeaux mixture, the first application being made when the leaves are half grown, and two more at intervals of about three weeks.

Figure 43. Plum leaf attacked by Shot-Hole fungus or Leaf-spot.

Winter Injury or so-called **Sun Scald**:—In 1896-97, following neglected cases of shot-hole fungus which defoliated the trees in the fall of '96, some plum orchards of Ottawa county were almost entirely destroyed by the severe winter freezing. The

[110] *Monilia fructigena* Pers.
[111] *Cylindrosporium Padi* Karst.

sappy trees were not in condition to withstand the severe cold, — 15 degrees. Young trees were killed to the snow line while older trees had the sides of the trunk, commonly that facing to the southwest, severely injured. The prevention of this trouble lies in the prevention of the shot-hole fungus and the avoidance of the conditions named. In some cases it is possible that protection of the trunk by straw or boards might be profitable.

POTATO.

Bacterial Blight: — This is a serious disease of the potato; it also attacks the tomato and egg-plant. It has been referred to a microbe.[112] The parts of the stem attacked die off suddenly and the tubers from the affected plants have a dark discoloration of the tissues in a distinct ring at a slight distance from the exterior of the potato. Fungicides are practically useless for this disease. Such diseased tubers should not be planted nor should potatoes follow a diseased crop of tomatoes, egg-plants or potatoes. (Div. Veg. Path. B. No. 12, U. S. Dept. of Agric.)

Early Blight of potato is a premature spotting and dying of the potato leaves, due to the work of a parasitic fungus.[113] The occurrence of the early blight, however, is liable to be influenced by the general vigor and other conditions of the plant; yet there is no just basis for denying, in the light of our present knowledge, the parasitic nature of this disease. Jones has made cultures of the fungus and produced the disease by inoculation (Vermont. Exp. Sta. Buls. 24 and 28; Rept. 1892) and has secured most admirable results by the use of fungicides. This successful spraying in itself is in the nature of proof of parasitic character. In the potato work at this Station it has been the uniform practice to spray thoroughly with Bordeaux mixture, adding arsenites for the insects, as required, and it has been many years since we have suffered any serious loss from early blight. However, the spraying for early blight will not prevent the bacterial disease above described, and it is doubtless the confusion of these two diseases that has led to such differences of opinion among potato growers as to the efficiency of spray-

Figure 44. Early Blight on potato leaf. (After Jones.)

[112] *Bacillus solanacearum* Smith.
[113] *Alternaria Solani* (E. & M.) Jones & Grant.

ing with Bordeaux mixture for early blight. Our recommendation is still that contained in the spray calendar, namely: to spray with Bordeaux mixture.

Late Blight or **Rot** of the potato is a fungous disease referable to a particular mildew fungus.[114] This mildew spots the leaves, producing a downy, felt-like covering in spots on the under side of the leaves of infested plants. It is said to prevail during wet seasons. While I have seen specimens that attest its actual presence in Ohio, I have never met with a case during six years of careful field work. Spraying is a successful remedy against it when found.

Figure 45. Tip-Burn of potato leaf. This is a simple drying up of the leaf borders. (After Jones.)

Potato Scab is a well known parasitic disease of the potato tuber that needs no extended description. Whether due to fungi or bacteria, or both, the practical prevention of potato scab consists in destroying the parasites on the seed potatoes and then in planting them in soil free from those organisms. The organisms in question will usually be found in soil on which potatoes were grown the previous year, or in that freshly manured. The materials used by this Station in treating for scab are two; namely, solution of corrosive sublimate and solution of formalin, as per strengths given in spray calendar. It is ineffective to treat the seed and then plant on scab-infested land.

A **Stem Rot** or **Dry Rot** especially on the Enormous variety is referred to a species of *Fusarium*. This disease is new with us. Remedies are left to the future.

PUMPKIN.

Downy Mildew and **Wilt** attack pumpkins after the manner described under muskmelon and cucumber. The remedies are the same as there stated.

QUINCE.

Fire Blight:— Fire blight is found in the quince as in the pear and is explained in the same manner. It requires the same treatment.

Leaf-spot and **Rot**:— Despite the ease with which it is grown, no other orchard fruit is left so much to the ravages of fungi as is the quince. Most conspicuous of these is the fungus[115] which attacks the leaves and fruit. In the fruit the spots are first small, circular, dark in color but subsequently will extend and more or less involve and ruin the whole. This fungus, as well as another, namely the leaf blight fungus of the pear, sometimes found upon the quince, is thoroughly held in check, or prevented, by applications of Bordeaux mixture.

[114] *Phytophthora infestans* D'By.

[115] *Sphaeropsis malorum* Berk.

RASPBERRY.

Anthracnose:[116] — The anthracnose fungus is a frequent bane to the raspberry grower. It attacks the young canes and so spots and injures them, as well as the foliage, that when the time arrives for ripening the fruit the plants are unable to do this and the crop is largely lost. The Horticulturist of this Station has always succeeded in holding this disease in check by the use of the methods of spraying recommended in the calendar for anthracnose. Care, however, must be used in the application of the spray to reach the stems of the young canes and to keep the fungicide from the leaves of bearing canes where it will do injury.

Figure 46. Raspberry stem attacked by Anthracnose.

Crown Gall is at present one of the most destructive diseases attacking raspberries. In some well marked cases upon the variety known as Thompson's Prolific (Bulletin 79) eelworms have been suggested as the possible cause of the gall production; but whatever the cause of the galls attacking that variety we have found them transmitted to the peach in the same soil and we have found that practically all of the varieties of raspberries are attacked by a similar trouble producing like excrescences. These galls result in the destruction of the bearing canes, and where the raspberries are planted in orchards the disease, it would seem, may extend to the orchard trees as well. Late investigations of Tuomey (Arizona, B. 33) show that a slime mold fungus is the cause of crown gall on the almond. Prompt removal and burning of all affected canes is the only method of treatment. Indeed it has been demonstrated from the very beginning that a healthy raspberry plantation cannot be secured by the selection of apparently healthy plants from diseased areas. Nothing remains but to secure plants from healthy plantations.

Figure 47. Crown Gall on raspberry plants. These also occur on the roots.

Bacterial Blight of raspberries has been described by this Station; it has not recently proved serious. (Bulletin 79).

[116] *Colletotrichum venetum* (Speg.) Hals.

Leaf-spot and **Rust:** — The leaf-spot fungus, already described for blackberries and dewberries, upon which it is more commonly found, was prevalent last season upon raspberries. The only remedy for rust is the removal and destruction of all clumps either wholly or partially infected. The leaf-spot fungus[117] will yield to spraying with Bordeaux mixture.

ROSE.

Nematodes: — Among the most serious of the rose diseases is that caused by the eelworms or nematodes which attack the roots. As with cucumbers, these parasitic worms induce the growth of small, bead-like galls upon the roots of the rose. The leaves dry up from the margins, the plants generally turning yellow and breaking down as the outcome of this interference with the proper work of the roots. This subject of nematodes is discussed at length in Bulletin 73. No successful remedy has been found for plants once attacked. The method of prevention consists, as in the case of cucumbers already cited, in the proper steaming and treatment of the soil designed for use in the rose benches.

Figure 48. Branch of rose root with Nematode Galls.

Rose Mildew is attributable to the fungus[118] which is commonly prevalent in rose houses; it is also found occasionally out of doors. This mildew is, for the forcing house, largely diagnostic; indicating, when prevalent, uneven temperatures. Proper attention to the matter of heat is the best preventive. Sulfur is often sprinkled upon plants and is frequently used upon the steam pipes, but it is not clear that the influence is very great.

Rose Leaf Blotch[119] often causes dark spotting of the leaves. The frost-like, branching growth over the leaf surface is often very pretty in design though injurious in effect. If the rosehouse is too moist, or if other conditions be slightly unfavorable, the fungus seems to flourish all the better. It may be checked by the use of Bordeaux mixture or by dilute copper sulfate solution, as recommended for cucumbers in the greenhouse (One pound to fifty gallons).

Rose Rust: — Two rusts[120] occur upon the rose in a wild state,

[117] *Septoria Rubi* West. *Caeoma nitens* Schw.

[118] *Erysiphe pannosa* Lév.

[119] *Actinonema Rosae* (Lib.) Fr.

[120] *Phragmidium speciosum* Fr. and *Ph. subcorticum* (Schw.) Wint.

but have not been met on cultivated roses here. In New Jersey (Report Exp. Sta. 1892) Dr. Halsted has met with rose anthracnose[121] and we have found two or three cases during the winter of 1899-1900.

RYE.

Ergot:[122] — This fungus has been known for a long time. It transforms the grain, after the manner of stinking smut of wheat. It is not extensively prevalent with us.

Rust: — Rye is attacked by about the same rusts as wheat.[123] See wheat.

Smut[124] is also found in rye, but the fungus in this case is peculiar to this plant. Hot water treatment for 5 minutes at 127 degrees F. has been recommended for this smut.

SORGHUM.

Bacterial Blight of sorghum is somewhat similar in its general appearance to the bacterial blight of corn already described. It has been described in the Kansas Exp. Station Report for 1888.

Sorghum Grain Smut[125] attacks the seed of the sorghum plant. Hot water treatment may doubtless be adapted to prevent this smut Head smut[126] is also known.

SPINACH.

Mildew: — The downy mildew fungus[127] is already known upon lamb's quarters and may appear upon the cultivated spinach of the same order. It shows discolored or dead spots in the leaves with felted, downy covering underneath. Methods of prevention here would be as for cucumbers, except that applications could scarcely be made after the plants are nearly developed.

Anthracnose, Scab and **White Smut** of spinach have not yet to my knowledge been discovered in Ohio.

SQUASH.

The squash is attacked by the diseases already described under cucumbers, namely, anthracnose, downy mildew and wilt. The remedies are likewise the same.

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[121] *Gloeosporium Rosae* Hals.
[122] *Claviceps purpurea* Tul.
[123] *Puccinia graminis* Pers. and *P. rubigo-vera* (DC.)
[124] *Urocystis occulta* (Wallr.) Rabh.
[125] *Cyntractia Sorghi-vulgaris* (Tul.) Clinton.
[126] *Ustilago Reiliana* Kühn.
[127] *Peronospora effusa* (Lév.) Rabh.

STRAWBERRY.

Strawberry Leaf-spot,[128] or **Rust,** so-called, is a well known spotting of the older strawberry leaves. The leaf-spot fungus matures in the old leaves.

Other fungi, of different species, may also be found on the strawberry, but the same statement holds true for the important sorts. While spraying may be useful, the practice of burning over strawberry beds to destroy old leaves and the fungi is based upon right principles. It is also commonly successful.

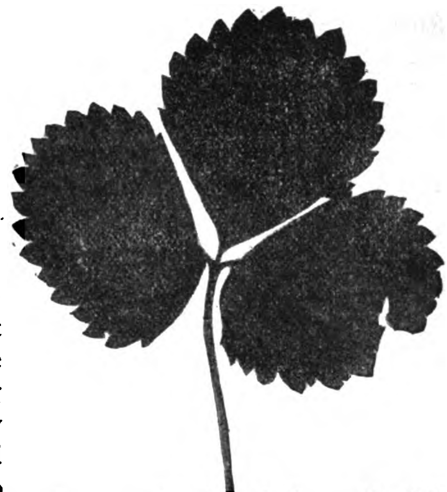

Figure 49. Strawberry Leaf-spot. The light centers have dark borders.

SUGAR BEET.

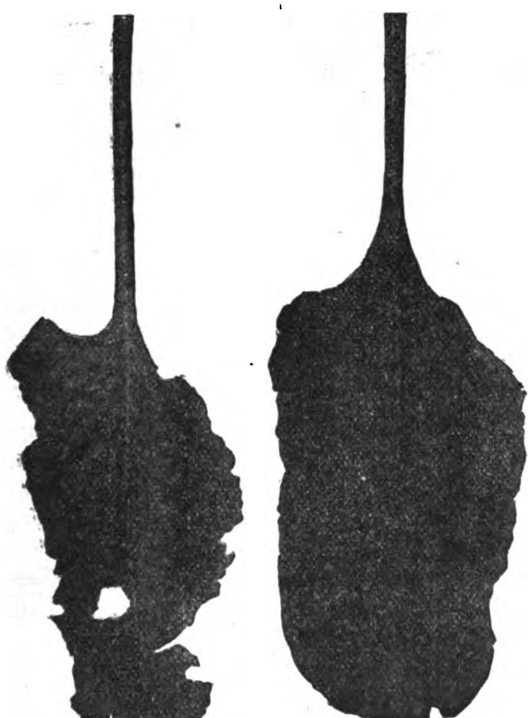

Figure 50. Leaf-spot trouble on sugar beet.

Leaf-spot:—The sugar beet, which is beginning to be extensively cultivated with us, has been injured by the leaf-spot fungus[129] and by other diseases. The leaf-spot produces small, dead areas in the beet leaves, followed at times by dying of all the leaves. For this fungus Bordeaux mixture may be applied with confidence, at intervals of three weeks. The first application should be made when the plants are about 5 or 6 inches high.

Beet Scab affects the roots of the beet as the scab does potato tubers. It is thought to be due to the same organisms. It may be avoided largely

[128] *Sphaerella Fragariae* (Tul.) Sacc.
[129] *Cercospora beticola* Sacc.

by avoiding the conditions for scab already mentioned under potato scab. Rotation of sugar beets will probably be required to escape these and other diseases.

SWEET POTATO.

Bin or **Soft Rot** is encountered by the sweet potato growers. The fungus[130] producing it may be present in the plant bed and apparent as dark spots or rotted tips on the plants at setting. All such plants ought to be discarded if avoidance of disease is sought. Some experiments were made at Marietta in 1897, to prevent or reduce this rot, but without positive advantage in the keeping qualities. A dope, or mixture of 6 parts earth to one part flowers of sulfur, was dropped in handfuls and the plants set through the mixture thus bringing it about the roots of the plant very nicely. Smoother potatoes were obtained and these separated more readily from adherent earth, but no better keeping resulted for that year. The potatoes were harvested, however, during a wet period and conditions were less favorable than is often the case.

Soil Rot[131] is a serious disease of sweet potatoes for which the above described treatment has proved successful in New Jersey. (N. J. Exp. Sta. B. 126).

Stem Rot[132] attacking the stems and roots has appeared in Ohio sweet potato fields, apparently introduced by affected seed. Such seed should be avoided. Rotation may also be necessary.

White Mold or **White Rot**[133] is common upon the Man-of-the-earth and the wild morning-glory *(Convolvulus hederacea)* in the sweet potato districts, but apparently is not frequent upon sweet potato foliage.

SYCAMORE.

Anthracnose[134] is often destructive on the foliage of this tree, and while it should be amenable to treatment with fungicides, it has been usually neglected.

TOMATO.

Anthracnose[135] occasionally causes small, depressed spots in tomatoes. It may be checked by the use of Bordeaux mixture.

Bacterial Blight of the tomato, egg-plant and potato has already been mentioned. It was destructive at Mt. Carmel, near Cincinnati, in 1896 (B. 73). It has since been locally destructive. It causes sudden blighting and decaying of the stems and branches attacked. Spraying has as yet proved useless for this blight. Preventive meas-

[130] *Rhizopus nigricans* Ehrh.
[131] *Acrocystis Batatas* Ell. & Hals.
[132] *Nectria Ipomoeae* Hals.
[133] *Cystopus Ipomoea-panduranae* (Schw.) Farl.
[134] *Gloeosporium nervisequem* (Fckl.) Sacc.
[135] *Gloeosporium phomoides* Sacc.

ures recommended include fighting insects, early removal of diseased vines, choice of fresh land not previously in potatoes or egg-plants, and tomato seed from healthy sources. To date, this disease has been less destructive than the leaf-spot.

Tomato Leaf-spot or **Leaf Blight** is an outdoor trouble, as are the two former. The leaf-spot fungus[136] appears to be gradually traveling westward from the Atlantic coast, where it first appeared several years ago. During 1898 it was locally disastrous over the whole of Ohio, and again during 1900. It may be successfully prevented by about three thorough sprayings with Bordeaux mixture, though some difficulty attaches to the treatment of unstaked tomato plants in the field. (Bulletins 73, 89, 105).

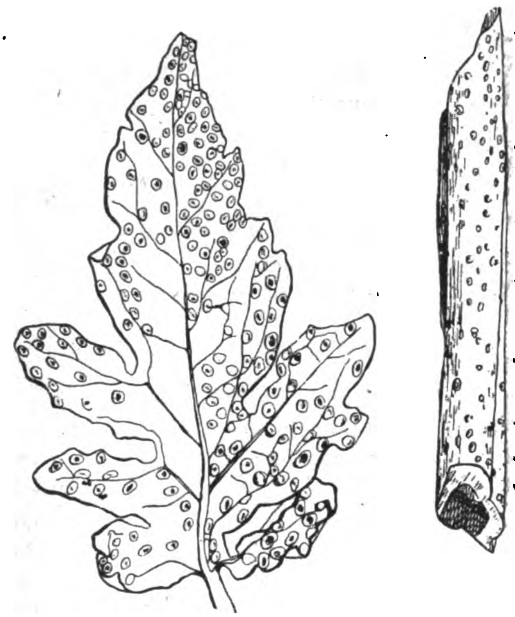

Figure 51. Tomato leaflet and stem attacked by Leaf-spot.

Nematodes may be very injurious to tomatoes grown under glass. They cause, as on cucumber plants attacked, gall-like enlargements on the small roots of the tomato. Previous soil treatment to destroy the nematodes is the remedy in this instance, as in the other. It will usually occur that tomato plants are less susceptible to injury by nematodes than are cucumbers and melons.

Leaf Mold[137] is a common trouble on tomato forcing-houses near the close of the season. It produces spots in the leaves, while beneath they are covered by the grayish-brown mold fungus. The fungicides heretofore recommended for use in the greenhouse are available for the tomato leaf mold.

Point Rot of green tomaotes, especially in the forcing-house, is often the most serious trouble with which the tomato grower under glass has to contend. It was stated in Bulletin 73 that this trouble was observed to be most destructive in cases of scant water supply in the soil. This observation was again confirmed by the Horticultural Department of the Station during the season of 1899. The trouble was checked by abundant and careful watering, even when it had been

[136] *Septoria Lycopersici* Speg.

[137] *Cladosporium* (?) *fulvum* Cooke.

very bad, and was again produced by withholding water and allowing the plants to dry out. The cause appears to be entirely physiological, and while other physiological causes than the one just stated may be conceived as competent to produce point rot, none other appears so likely or so common. The remedy lies, of course, in the avoidance of conditions from which the rot may result.

TURNIP.

Club-root: — This fungus organism[138] infests the roots of many cultivated mustard plants, including the turnip, radish, rutabaga, etc. The treatment is the same as stated under cabbage.

VERBENA.

Mildew: — Cultivated verbenas are attacked by the mildew[139] which is so common on the wild vervains. It is to be treated as other powdery mildews, by spraying with fungicides.

VIOLET.

Leaf-spot and **Leaf Blight**[140] are sometimes prevalent, and with downy mildew of violet should yield to spraying with fungicides.

Nematodes of violets are, on the other hand, not amenable to spray treatment. The parasite in the case is the same as named under cucumber nematodes, likewise its effects. Soil treatment will also be effective in prevention here.

WATERMELON.

With the possible exception of the wilt disease and the leaf-spots the diseases of the watermelon are the same as those which attack cucumbers and muskmelons. They include anthracnose, downy mildew and leaf blight. The leaf-spot of the watermelon is referred to a distinct fungus[141] though its ravages are, possibly, not general. (See Bulletins 73, 89, 105). In the treatment of watermelon vines it is advisable to use the more dilute Bordeaux mixture, Bordeaux II, of the calendar.

WHEAT.

Rust: — While essentially the same, to the ordinary vision, wheat rust is produced by two rust fungi,[142] of which only the last named may pass the winter in the wheat plant. Both have the red and the black (dark) stages and are very damaging under, to them, favorable conditions of weather and grain. In Europe, Australia and

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[138] *Plasmodiophora Brassicae* Wor.

[139] *Erysiphe Cichoracearum* DC.

[140] *Phyllosticta Violae* Desm. and *Cercospora Violae* Sacc.

[141] *Cercospora Citrullina* Cke.

[142] *Puccinia graminis* Pers. & *P. rubigo-vera* (DC).

California wheat growers hope to select rust-proof varieties of wheat, and this is, as yet, the only promise of rust prevention on wheat. (Bulletin 97).

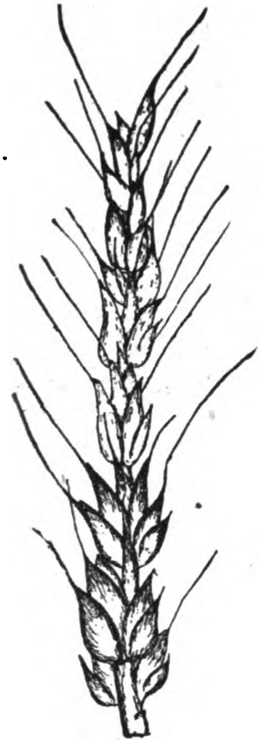

Figure 52. Wheat spike with Scab; the upper portion has been destroyed by the pink fungus.

Figure 53. Heavy spike of bearded wheat destroyed by Loose Smut.

Figure 54. Smutted and sound spikes of Poole wheat; in one at left the kernels have been destroyed by Stinking Smut and spikelets are spread abruptly.

Wheat Scab: — This is also due to a particular fungus,[143] which attacks the rachis and the glumes of certain wheat heads, producing on these heads a reddish or pink incrustation, and destroying that part of the spike. This fungus survives the winter in its perithecial form upon wheat heads, straw, etc. It is liable to be worse when a crop of diseased wheat has preceded the wheat. No remedy beyond avoidance has been proposed. (B. 97).

Loose Smut: — This is a smut fungus[144] which converts grain and glumes into a sooty mass of spores. These heads of loose smut are most obvious at the blossoming of the wheat. The disease is worse on certain varieties of wheat. It may be prevented by the modified hot water treatment as per calendar.

[143] *Fusarium roseum* Lk.

[144] *Ustilago Tritici* Jensen.

Stinking Smut of wheat is caused by a still more destructive smut fungus,[145] which converts the kernels of wheat into dirty, stinking masses of spores. These, if abundant, ruin the flour and render the wheat valueless for human food. At times 40 percent of the wheat is thus destroyed and the losses from it are often very large. Recent investigations have established that this smut is caused by the smut spores sown with the seed grain. If the smutty seed wheat is treated with a fungicide, such as bluestone, hot water, formalin, etc., which will destroy these spores without injury to the grain and the treated seed is then prevented from subsequent infection, dried and sown, a clean crop may be grown from smutted seed. For details of treatment see calendar and Bulletin 97, which treats of the diseases of wheat.

[145] *Tilletia foetens* B. & C.

SEED AND SOIL TREATMENT AND SPRAY CALENDAR*

FOR INSECT PESTS AND PLANT DISEASES.

PREPARED BY W. J. GREEN, A. D. SELBY AND F. M. WEBSTER.

This Bulletin is designed to cover the needs of farmers and horticulturists. It was first prepared as a spray calendar at the request of the Ohio State Horticultural Society. Insecticides and Fungicides may often be combined in spraying, and, where Bordeaux mixture is used for fungous diseases this practice is recommended. Spraying young orchards with Bordeaux mixture from time of planting, and of stocks in nursery row, is strongly recommended to preserve healthy conditions.

FUNGICIDES.

1. Bordeaux Mixture I.

Copper sulfate (blue vitriol) 4 pounds.
Quicklime (not air slaked) 4 pounds.
Water, to make 50 gallons.

Dissolve the copper sulfate in about two gallons of hot water, contained in a wooden vessel, by stirring, or even better, by suspending the sulfate contained in a cheese cloth sack, in a large bucketful of cold water. With the cold water and cheese cloth bag, a longer time is required. Pour the sulfate solution into the barrel or tank used for spraying, and fill one-third to one-half full of water. Slake the lime by addition of a small quantity of water, and when slaked cover freely with water and stir. Pour the milk of lime thus made into the copper sulfate, straining it through a brass wire strainer of about 30 meshes to the inch. Pour more water over the remaining lime, stir and pour into the other; repeat this operation until all the lime but stone lumps or sand is taken up in the milk of lime. Now add water to make 50 gallons in the tank. After thorough agitation the mixture is ready to apply. The mixture must be made fresh before using, and any left over for a time, should be thrown out or fresh lime added.

2. Bordeaux Mixture II.

Copper sulfate, 2 pounds.
Quicklime, 2 pounds.
Water, to make 50 gallons.

For use on such trees as have foliage injured by Bordeaux I.

STOCK SOLUTION.

A solution of copper sulfate containing say one pound of sulfate to the gallon of water may be made up and permitted to stand indefinitely in a covered barrel if no lime is added. Such a solution is known as a stock solution, and two or four gallons of this stock solution, according to the strength desired, are taken for each 50 gallons of mixture to be made. For extensive spraying, a long trough or box of uniform width may be used in which to slake and keep the lime. The quicklime is weighed out according to the amount needed immediately, placed in the trough and slaked with a small quantity of water. The whole is evenly spread and covered as a putty, with water to exclude the air. This putty may be removed in calculated portions, placed in a tub and treated like the freshly slaked lime. By means of stock solution of copper sulfate and the lime in putty state, much valuable time is saved in filling the barrels or tanks used in spraying. [By suspending the blue vitriol in cheese cloth bag just below surface of water, 40 pounds will dissolve readily over night in 40 gallons of water.]

3. Ammoniacal Solution of Copper Carbonate.

Copper carbonate, 6 ounces.
Ammonia, about 3 pints.
Water, 50 gallons.

Dissolve the copper carbonate in the ammonia and add the water.

Caution: Use no more ammonia than is required to dissolve the copper carbonate. Ammonia is variable in strength, and the amount required must be tested in practice.

To make copper carbonate: Dissolve 10 pounds copper sulfate (blue vitriol) in 10 gallons of water, also 12 pounds carbonate of soda in same quantity of water. When cool, mix the two solutions slowly, stirring well. Allow the mixture to stand twelve hours and settle, after which pour off the liquid. Add the same quantity of water as before, stir and allow to

* Reprint of Bulletin No. 102.

stand the same length of time. Repeat the operation again, after which drain and dry the blue powder, which is copper carbonate.

4. Copper Sulfate Solution.

Copper sulfate, 4 pounds.
Water, to make 50 gallons.

Dissolve the sulfate as directed in Bordeaux I.
Caution: This solution will injure foliage. It can be used only before the buds open.

5. Potassium Sulfid Solution.

Potassium sulfid (liver of sulfur) 1 ounce.
Water, 3 to 4 gallons.

This solution will not remain unchanged. The potassium sulfid must be kept in a well stoppered bottle.

6. Formalin.

For oats and wheat, 1 pound (1 pint) formalin to 50 gallons water.
For potatoes, ½ pint formalin to 15 gallons of water.

7. Corrosive Sublimate.

Corrosive sublimate, 2 ounces.
Water, 15½ gallons.
Label **Poison**; used for potato scab and disinfection.

To hasten solution, have druggist pulverize the sublimate.

INSECTICIDES.

8. Kerosene Emulsion.

Dissolve one-half pound hard soap in one gallon of water (preferably soft water) and while still boiling hot, remove from the fire and add two gallons of kerosene. Stir the mixture violently by driving it through a force pump back into the vessel, until it becomes a creamy mass that will not separate. This requires usually from five to ten minutes. The emulsion is then ready to be diluted with water and applied. For the common scale insects and hard bodied insects, like the chinch bug, use 1 part emulsion to 8 or 10 parts water. For soft bodied insects (plant lice, etc.) use 1 part emulsion to 15 or 20 parts water.

Kerosene emulsion kills by *contact* and therefore the application should be very thorough. It may be used against a great many different pests, but is especially valuable for destroying those with sucking mouth-parts, for they cannot be killed with arsenical poisons.

9. Paris Green.

In combination with Bordeaux mixture, Paris green may be used at the rate of 1 pound to 175 to 200 gallons.

When Bordeaux mixture is unnecessary, the Paris green may be used at the same rate, but 2 or 3 pounds of freshly slaked lime must be added to prevent burning of the foliage. Keep the mixture well stirred so that the poison will be distributed evenly.

In cases where successive sprayings are necessary, it is important to consider the accumulation of poison and use a slightly weaker mixture, unless sufficient rain has fallen to wash off the poison thoroughly.

10. London Purple.

If desirable, London purple may be substituted for Paris green, but it has the disadvantage of being somewhat variable in composition and contains more soluble acid. For that reason it must be used somewhat weaker, or else an abundance of lime provided, so as to prevent burning of foliage. It has the advantage of not settling as readily as Paris green.

11. White Hellebore.

Hellebore is often employed in cases where arsenical poisons would be objectionable. Use one ounce to three gallons of water.

12. Pyrethrum.

Pyrethrum is usually applied as a powder, with a bellows, but may be used as a spray at the rate of one ounce to two gallons of water.

13. Whale Oil Soap Solution.

Use from one to two pounds of the soap to one gallon of water. Be sure that the soap is thoroughly dissolved, and then apply in form of spray. 1 pound to gallon of water if used for peach leaf curl only.

14. Arsenite of Soda.

Dissolve two pounds of commercial white arsenic and four pounds of carbonate of soda (washing soda) in two gallons of water and use one and one-half pints to a barrel of Bordeaux Mixture (50 gallons).

The easiest way to make the solution is to put both the white arsenic and carbonate of soda in a gallon of boiling water and keep boiling about fifteen minutes, or until a clear liquid is formed, and then dilute to two gallons.

Caution: — Label this solution **Poison** as it is colorless.

SEED AND SOIL TREATMENT.

Seed or Plant.	For What Treated.	Treatment.	Method of Treatment.
Barley	Smuts	Modified hot water	Soak seed enclosed in sacks 4 hours in cold water, let stand wet 4 hours more and dip 5 minutes in hot water at 130 degrees F., or three degrees lower than for other hot water treatments.
Bean	Anthracnose	(See spray calendar.)	
	Weevil	Bisulfid of carbon	Submit to fumes for 24 hours in air-tight vessel.
Begonia	Nematodes	Heat soil with steam	Disinfect soil to be used by heating with steam as described under cucumbers.
Cabbage and Cauliflower	Club root	Quicklime on soil	Apply stone lime (quicklime) before planting, at rate of 80 bushels per acre and work into soil with tools.
	Maggot	Bisulfid of carbon	Make hole in soil near roots, pour in about a teaspoonful of bisulfid of carbon and fill hole with soil.
Cucumber	Nematodes in hot-house	Heat soil with steam	Heat earth before using in a special box for 3 hours with 60 lbs. of steam, or 4 hours with 40 lbs. See Bulletin 73.
Oats	Loose smut	Immerse seed in hot water. Soak seed in Potas. sulfid. Sprinkle seed with formalin or copper sulfate	Immerse seed contained in open vessel for 10 minutes in hot water at 132-3 degrees F., for 7 minutes at 136 degrees F., or for 5 minutes at 140-2 degrees F., spread at once to dry. (2.) Soak seed in ¾ per cent. solution potassium sulfid for 24 hours with stirring, then dry. (3.) Sprinkle a pile of seed to saturate with formalin or copper sulfate, one gal. to bu. After 2 to 3 hours spread to dry. For latter use lime in drying. See Bulletin 97.
	Insects in stored grain	See wheat.	
Onion	Smut	Plant other crop. Use sets or transplanted seedlings. Sprinkle seed before covering, with formalin, as for oats	The soil once infected by spores of onion smut cannot easily be freed from them. Long planting in other crops or use of sets or transplants yields favorable results.
Potato	Scab	Soak uncut seed in corrosive sublimate or formalin	Soak seed for one hour in corrosive sublimate, or for 2 hours in formalin, then dry and plant on scab free soil.

SEED AND SOIL TREATMENT.

Seed or Plant.	For What Treated.	Treatment.	Method of Treatment.
Roses	Nematodes in hot-house	Heat soil with steam	Heat soil with steam as described above; thoroughly disintregated soil from sod one year or more old is less dangerous. Lime water stimulates affected plants, but is not a remedy.
Sweet Potato	Bin rot	Use flowers of sulfur in soil	Make dope 1 part flowers of sulfur and 6 parts earth:—Drop handful and set plant through it.
	Soil rot	Use flowers of sulfur	(Same as above.)
Tomato	Nematodes in hot-house	Heat soil with steam	As for roses and cucumbers above.
	Point rot in hot-house	Mulch or subwater	A supply of available water appears to be unfavorable to point rot of green tomatoes.
Turnip	Club root	Quicklime in soil	As for cabbage and cauliflower. Avoid succession of mustard crops.
Violet	Nematodes in hot-house	Heat soil by steam	The time for prevention is by soil treatment beforehand, as for cucumbers above.
Wheat	Loose smut	Modified hot water	Soak seed 4 hours in cold water, let stand 4 hours more in wet sacks, immerse 5 minutes in water at 133 degrees F. and dry.
	Stinking smut	Hot water, copper sulfate or formalin	Dip skimmed seed for 10 minutes in hot water at 133 degrees F. and dry on disinfected surface, or immerse 10 minutes in blue stone, dry with air slaked lime by shoveling. Use 2 lbs. blue stone to 10 gals. water. Grain may be sprinkled with copper sulfate or formalin, as for oats. See Bulletin 97.
	Insects in stored grain	Bisulfid of carbon	Place one pound of bisulfid of carbon for each 2,000 lbs. of grain in bins. Cover surface to hold the fumes which will spread through the mass, killing all insect life. Use in tight bins or buildings and do not use near fire of any description.

SPRAY CALENDAR.

What to Spray.	For What to Spray.	With What to Spray.	When to Spray.	
			First Spraying.	Second Spraying.
Apple	Bitter rot	Ammoniacal cop. carb.	With first appearance of rot.	Two weeks after first
	Scab	Bordeaux mixture I.	As buds are swelling	Just before blossoms open
	Sooty fungus	Bordeaux I	After blossoms drop	Two weeks later
	Bud moth	Arsenites in Bordeaux I	With opening of buds	
	Canker worm	Arsenites alone, 9 or 10	With first young worms	In 1 week if worms remain
	Codlin moth	Arsenites in Bordeaux I	As soon as blossoms fall	7 to 10 days later
	San Jose scale	Whale oil soap solution	As soon as leaves drop in fall	Just before fol. starts in Sp
	Woolly aphis	Kerosene emulsion	When trees are not in full leaf	In fall
Aster	Blister beetle	Whale oil soap	When beetles appear	
Asparagus	Asparagus Beetle	Lime or Pyrethrum	Early spring	
Bean	Anthracnose	Bordeaux I	Soak seed 1 to 2 h. in am cop. car. five times strength of 3	Bord. on 2 to 3 in. plants
Beet	Leaf spot	Bordeaux I	When plants are 5–6 in. high	Two weeks after first
Cabbage and Cauliflower	Cabbage worm	Pyrethrum	With first appearance of worms	Whenever worms observed
	Club root	(See soil treatment.)		
Carnation	Leaf or calyx mould	Bordeaux I or ½ of 4	Upon appearance of fungus.	Two weeks later
	Leaf spot	Bordeaux I or ¼ of 4	Upon appearance of fungus.	Two weeks later
Celery	Leaf spot or leaf blight	Bordeaux I	On young seedlings	Repeat on seedlings
Cherry Stocks	Leaf spot	Bordeaux II	When leaves are half grown.	Two weeks later
Cherry	Leaf spot	Bordeaux II	When leaves are unfolding	Two weeks later
	Rot (?)	Bordeaux I and II	Before blossoming I	After bloss. drop II. fruit
	Aphis	Whale oil soap	On first appearance of aphis	
	Cherry slug	Arsenites in Bord. II	When slugs appear	Repeat if slugs remain
	Curculio	Arsenites in Bord. I and II	Before blossoming in I	As blossoms dry up in II
	San Jose scale	Whale oil soap solution	In fall as with the apple	As with the apple.
Cinerarias	Mildew	Bordeaux I or ¼ of 4	When mildew appears	Two weeks later
Chrysanthemum	Leaf spot	Bordeaux II or ¼ of 4	July 1	Two weeks later
Cucumber	Anthracnose	Bordeaux I	When plants begin to vine	Two weeks later
	Downy mildew	Bordeaux I	July 25 to August 1	Eight to ten days later
	Spot of fruit	Bordeaux I	After first blossoms	Ten days later
Currant	Leaf spot	Bordeaux I	As leaves are unfolding	Two weeks later
	Plant bug	Kerosene emulsion	May	Early June if necessary
	San Jose scale	Whale oil soap solution	As with the apple	In spring as with apple
	Worm	White hellebore	When worms first appear	In 3 or 4 days repeat
Gooseberry	Leaf spot	Bordeaux I	As currants with leaf spot.	As currants with leaf spot
	Mildew	Bordeaux I or 5	Before leaves open I	After blossoming I
	Worm	White hellebore	As on currants.	
Grape	Anthracnose	Bordeaux I	Just before buds open	Just before blossoming
	Berry moth	Arsenites, with Bordeaux I		After fruit has set
	Downy and powdery mildew	Bordeaux I	Just before blossoming	After fruit has set
	Rot	Bordeaux I and 3	Just before buds open Bord I	Just before blossoming I
	Leaf hopper	Kerosene emulsion	Before young can fly	
Horse Chestnut	Leaf spot or blight	Bordeaux I	When leaves are half grown	Two weeks later
Muskmelon	Anthracnose	Bordeaux I and II	In seed bed or when plants begin to vine Bordeaux I	Two weeks later Bord I
	Downy mildew	Bordeaux I	July 25 to August 1	Eight to ten days later
	Leaf blight	Bordeaux I	When plants begin to vine	Three weeks later

SPRAY CALENDAR—Continued.

For What to Spray.	When to Spray.		Remarks and Cautions.
	Third Spraying.	Fourth Spraying.	
Bitter rot	Two weeks later	Not required if Bord. precedes	These follow Bord. for scab; danger on fair skinned apples.
Scab	Just after blossoms drop	7 to 10 days later	
Sooty fungus	These coincide with 3d and	4th for scab.	
Bud moth			
Canker worm	Same as second		
Codlin moth	These coincide with 3d and	4th for scab. Paris green alone on light apples.	White skinned apples are injured by spraying after 3d.
San Jose scale	....	....	Two lbs. soap dissolved in 1 gallon water.
Woolly aphis	....	....	Don't use emul. when trees are in full leaf.
Blister beetle	....	....	Use 1 lb. soap to 6 gals. water.
Asparagus Beetle.	....	....	Do not use arsenites, except in late summer.
Anthracnose	Bordeaux 10 days later	After blossoms	Repeat if needed.
Leaf spot	Two weeks later		
Cabbage worm	....	....	1 oz. to 3 gallons water, or dust 1 to 10 of flour.
Club root			
Leaf or calyx mould	Two weeks later	Repeat if needed	Begin early before calyces are ruined.
Leaf spot	Two weeks later	Cover foliage well.	
Leaf spot or leaf blight	Before or after transplanting	Two weeks later	Keep leaves well covered in plant bed.
Leaf spot	Two weeks later	About two weeks later.	
Leaf spot	2 or 3 weeks after second	....	First after blossoming.
Rot (?)	Two weeks later II on fruit.	Two weeks later II or 3	Use 3 when fruit is large.
Aphis	....	....	Difficult to reach aphis. Use 1 lb. soap to 6 gals. water.
Cherry slug	....	....	Air slaked lime may be used.
Curculio	One week later in II	....	Avoid strong solutions.
San Jose scale			
Mildew	Repeat if necessary.		
Leaf spot	Repeat if necessary.		
Anthracnose	Two weeks later	Two weeks later	Repeat as necessary.
Downy mildew	Eight to nine days later	Eight days later	Repeat at weekly intervals.
Spot of fruit	Two weeks after second	Two weeks after third	Apply to fruit carefully.
Leaf spot	Two weeks later	Two or three weeks later	Fourth necessitates washing fruit.
Plant bug			
San Jose scale			
Worm	Repeat as second.		
Leaf spot	As currants with leaf spot	As currants with leaf spot	This remedy is very successful.
Mildew	Potass. sulfid 2 weeks later.	....	Bord. coats fruit if used for 3d.
Worm			
Anthracnose	Just after fruit has set	Ten days later, Bordeaux	Don't spray after fruit is half grown.
Berry moth	Ten to fourteen days later	....	Do not spray with arsenites after July 1st.
Downy and powdery mildew	Ten to fourteen days later	....	Covered by spraying for anthracnose or rot.
Rot	Just after fruit has set I	Ten days later, Bordeaux	Follow by two or three sprayings with am. cop. carb.
Leaf hopper			
Leaf spot or blight	Two weeks after 2	Two or three weeks later.	
Anthracnose	Two weeks later	Two weeks later	Repeat as necessary, use II very early.
Downy mildew	Eight to nine days later	Eight days later	Repeat same.
Leaf blight	Three weeks after second	Two weeks after third.	

SPRAY CALENDAR—Continued.

What to Spray.	For What to Spray.	With What to Spray.	When to Spray. First Spraying.	When to Spray. Second Spraying.
Oats	(See seed treatment).			
Peach	Leaf curl	Bordeaux 1, 4 or 13 and II	In fall, or in March, Bordeaux I or 4	As buds are opening 1 or 4. Also 13.
	Pustular spot	Bordeaux II	Just after calyx drops	Two weeks after first
	Rot	Bordeaux I and II	As buds are swelling I	Just after calyx drops, II
	Scab	Bordeaux I or 4 and II	As buds are swel. Bord. I or 4	Just after calyx drops Bord. II
	Bud moth	Arsenites in Bordeaux I	With opening of buds	
	San Jose scale	Whale oil soap solution	As buds are opening in spring	
Pear Stocks	Leaf spot or blight	Bordeaux I	When leaves are half grown.	Two weeks later
Pear	Leaf blight	Bordeaux I and 8	When leaves are half grown.	Two weeks later
	Scab	Bordeaux I	Before blossoms open	After blossoms drop
	Bud moth	Arsenites in Bord. I.	With opening of buds	
	Canker worm	Arsenites in Bord. I.	As with the apple	
	Codlin moth	Arsenites in Bord. I.	After blossoms fall	Seven to ten days later.
	San Jose scale	Whale oil soap solution	As soon as leaves drop in fall	Just as fol. starts in spring.
	Slug	Arsenites in Bord. I or dust with slaked lime	When slugs appear	Repeat if slugs remain.
Pea	Mildew	Bordeaux I	When mildew appears	Two weeks later
Plum	Rot	Bordeaux I, also 3	As buds are swelling I	Just after calyx drops I
	Shot-hole fungus.	Bordeaux I	When leaves are half grown.	Three weeks later
	Curculio	Arsenites in Bord. I.	With starting of buds	Just after calyx drops
	Aphis	Whale oil soap	On appearance of aphis	
Potato	Early blight	Bordeaux I	When plants are 6 in. high.	Two weeks later
	Late blight	Bordeaux I	As for early blight in all	
	Blister beetle	Whale oil soap	When beetles appear	Repeat if necessary.
	Colorado beetle	Arsenites alone or in Bord. I	When beetles or young appear	As for first
	Flea beetle	Bordeaux I	When beetles appear	Repeat if necessary.
Quince Stock	Leaf spot	Bordeaux I	When leaves are half grown.	About two weeks later
Quince	Leaf spot	Bordeaux I	As buds are swelling	When leaves are half grown
	Fruit and leaf spot	Bordeaux I	Before blossoms open	After blossoms drop
Raspberry and Blackberry	Anthracnose	Bordeaux I and II	Before leaves open use I	II on young canes 6 in. high
	Leaf spot	Bordeaux I	When leaves are half grown.	Two weeks later
	Saw fly	Pyrethrum or hellebore	As for currant worm	In 3 or 4 days repeat.
Rose	Leaf spot	Bordeaux I or ½ of 4	With first appearance of fungus	Two to three weeks later
	Slug	Arsenites in Bordeaux II or hellebore	On appearance of slugs	Repeat if needed.
Sugar Beet	Leaf spot	Bordeaux I	With first appearance of spots	Two to three weeks later
	Blister beetle.			
	Flea beetle	Bordeaux I	When beetles appear	
Tomato	Anthracnose	Bordeaux I	Soon after fruit begins to set	Three weeks later
	Leaf blight	Bordeaux I	Three weeks after transplanting	Three weeks after first
Watermelon	Anthracnose	Bordeaux II	When plants begin to vine.	Three weeks after first
	Downy mildew	Bordeaux II	July 25 to August 1	Eight to ten days later
	Leaf blight	Bordeaux II	As disease appears on muskmelon	Repeat as on muskmelon.

SPRAY CALENDAR — Concluded.

For What to Spray.	When to Spray. Third Spraying.	Fourth Spraying.	Remarks and Cautions.
Leaf curl	Just after calyx drops Bord. II	Not required, ditto 8, if others well done	Whale oil soap serves as second
Pustular spot	Two weeks later		Cover fruit well.
Rot	Three to four weeks later II.	As fruit begins to color II.	Every 7-10 days repeat. Destroy all mummies. 8 may be used 4th.
Scab	Two weeks later Bord. II	Two weeks later Bordeaux II.	
Bud moth			Use only half usual amount of poison.
San Jose scale			Two. lbs. soap to 1 gal. water. Use only in spring as buds are opening.
Leaf spot or blight	Two weeks later	Two weeks later	5 to 7 sprayings are needed.
Leaf blight	Two weeks after second	Bord. may make russet fruit	Use 8 for 3d; not Bord. after 2d.
Scab			Bordeaux after second may injure fruit.
Bud moth Canker worm Codlin moth San Jose scale			Two lbs. soap dissolved in 1 gallon water.
Slug			
Mildew	Repeat if needed.		
Rot	Three or four weeks later I.	As fruit begins to col. use 3	Every 7-10 days repeat 4th; useless to spray for rot, unless mummies are destroyed.
Shot-hole fungus	Three weeks later, if needed.		
Curculio	Five days later		Jar and gather stung plums in addition.
Aphis			Use 1 lb. soap to 6 gals. water.
Early blight Late blight	Two weeks later	Two weeks later if needed	
Blister beetle Colorado beetle	As for first and second.		
Flea beetle			
Leaf spot	Two weeks later	Two weeks later	Perhaps 5th spraying will be needed.
Leaf spot	Two weeks later	Two weeks later	Second should come after blossoms drop.
Fruit and leaf spot	Two weeks after second	Two weeks later.	
Anthracnose	Repeat second one week later		Keep spray from leaves on bearing canes.
Leaf spot Saw fly	Two weeks later.		
Leaf spot	Repeat if necessary		Bordeaux shows on plant.
Slug			
Leaf spot	Two to three weeks later	Three weeks later if needed.	
Blister beetle Flea beetle			Bordeaux I some danger.
Anthracnose	Three weeks later.		
Leaf blight	Three weeks later	Three weeks later	
Anthracnose	Two weeks later	Three weeks later	
Downy mildew	Eight to nine days later	As for cucumbers	Bordeaux I some danger.
Leaf blight	As on muskmelons		

Ohio Agricultural Experiment Station.

BULLETIN 122

WOOSTER, OHIO, DECEMBER, 1900.

ONION SMUT

PRELIMINARY EXPERIMENTS

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BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 122 DECEMBER, 1900.

ONION SMUT—PRELIMINARY EXPERIMENTS.

BY A. D. SELBY.

INTRODUCTION.

There are comparatively few persons who have not some knowledge of the methods commonly followed in growing onions. This vegetable is widely cultivated in our state, yet its culture on a large scale is limited to comparatively few districts which possess soils especially adapted to this crop, or in which particular branches of onion growing have been developed. One recalls readily the large fields of onions commonly grown upon muck land, notably in the swamps of many counties in northern Ohio. Similar development has occurred near Lake Erie and in the bottoms along the Ohio river. In general the onion crop is grown from seed. The bulk of the Ohio crop is produced from seed, planted in single drills in very early spring and often cultivated in considerable areas. The comparatively small proportion of the total yield produced from sets or from mother onions will become apparent to any one who investigates this subject. This last named method of propagation of onions is confined chiefly to the market gardeners, who seek to place upon the early market a liberal supply of young, green onions. Yet a still smaller area is devoted to growing small onions from seed; these are destined for use as sets. This set growing from seed is a branch of onion culture practiced in the vicinity of Chillicothe, where in the aggregate large areas are planted every year. In most districts more or less attention is devoted to the growing of onion seed. Perhaps little interest for the student of plant diseases would attach to the methods of

devoted to grape culture are factors of no inconsiderable importance when grape rots prevail.

Following the experiments made in France and in the United States from 1885 to 1889, vineyardists soon learned to master the black rot and mildew which then assailed them, while the industry in northern Ohio generally flourished and the area in vineyards extended during the decade stated. But the competition from large production of basket grapes in the New York grape belt, and the development of the industry in Michigan and Wisconsin, as well as in other states, where Ohio grapes formerly found a market, following upon the decline of the wine industry, has left Ohio grape growing in a languishing condition.

Beginning conspicuously in 1896 and 1897, rotting of the grapes near the ripening period lessened production, first in Ashtabula county, while this rot subsequently extended westward. The attacks of the grape rootworm became destructive in the Euclid district at about the same time, while competition reduced the price of grapes below that formerly estimated to be the cost of production. The inevitable results of diminished incomes and shrinking land values, where not modified by suburban extension, were soon to be noted, and certain other unfavorable conditions followed; vineyards were occasionally removed but perhaps more often permitted to remain and very frequently neglected.

GRAPE CONDITIONS MORE UNFAVORABLE IN 1898 AND 1899.

Matters were not improved for the Ohio grape growers during 1898 and 1899, and a ripe rot, perhaps more properly called the white rot, extended over much greater areas till now in 1900 scarcely a locality is free from it.

It may be thought that a recital of these conditions has little bearing upon the problem of grape rot prevention, but not so from the writer's experience. It has been found that a languishing industry offers a very unfavorable basis for successful experimentation. Proper tying, cultivation and pruning are not always contemplated under these circumstances, while many neglected vineyards in every neighborhood are breeding places for fungus spores. More than this, the attitude of the public is one of dissatisfaction and distrust, manifesting itself in opposition, sharp criticism and in a general unwillingness either to take measures for the betterment of these conditions or to permit others to do so without obstruction. A picture so clouded is happily relieved by a few active and progressive spirits, ready to aid in every way possible and to expend time and money for the general good. To such the obligations of the investigator are very great.

THE VARIOUS GRAPE DISEASES.

Several diseases prevailing in Ohio require to be mentioned and briefly discussed here, the better to distinguish the most destructive.

The Anthracnose fungus *Sphaceloma ampelinum* D'By) is found upon the leaves and young stems as well as upon the fruit; it produces sunken spots of a definite outline, usually with a central area of lighter color. Upon the fruit this appearance is well marked and has given rise to the name "bird's-eye-rot." (Figure 1.) Grapes attacked in this manner are readily distinguished from those attacked by the other rots because of the difference in appearance and the slower spread of the trouble; such as are badly marked, like those in the illustration, are unfit for market. The losses from anthracnose are commonly not large. This disease may be entirely prevented by the use of Bordeaux mixture as directed in the calendar.

A Bitter Rot of the grape is likewise known; it is late in making its appearance and the rotted grapes have a very bitter taste; not known to be important with us. (The fungus of bitter rot is *Melanconium fuligineum* Scribner & Viala.)

Downy Mildew or Brown Rot is a somewhat common fungous disease of the grape. The fungus of this mildew (*Plasmopara viticola* (B. & C.) Ber. & D'Ton.) may be discovered upon the leaves by the slight yellow spotting of the upper leaf surface while there is a downy, felted covering of the under surface. A great abundance of summer spores is also produced upon these felted spots beneath. Resting spores are produced within the leaves in the form of "oospores," which will be destroyed by burning the fallen leaves. This same fungus also attacks the grape berry causing brown rot, in which the berries are light brown in color throughout. (See Bulletin, Vol. III, No. 10.) Spraying with Bordeaux mixture will prevent both forms of the downy mildew trouble if the work be thoroughly done as directed.

The Powdery Mildew fungus (*Uncinula necator* Schw.) attacks both leaves and fruit of unsprayed grapes in the form of a white web-like covering. For this also, Bordeaux mixture is a specific.

Grape Canker or Frost Injury shows as enlargements upon the older vines at points injured by freezing. These enlargements do not indicate more than healing growth.

Crown Gall may come on nursery vines as excrescences near the surface of the earth; it is a contagious disease, calling for the burning of all infected vines.

Phylloxera is an insect trouble apparent as warty enlargements upon the under leaf surfaces of European strains like Delaware, Brighton and others; the excrescences are often covered with the powdery mildew fungus. It does not attack pure American sorts.

(For Grape Root Worm see Bulletin 62, by the Entomologist of this Station.)

Black Rot is also to be referred to a fungus *Laestadia Bidwellii* (Ell.) Viala & Ravaz.) and ranks as one of the most destructive grape troubles. Some of the earlier achievements of the vegetable Pathologist dealt with this fungus and attained its satisfactory and profitable control. It attacks young stems, the leaves and the young fruit, being especially destructive upon the latter. Discussion has been reserved to be placed in juxtaposition to that of white rot.

Upon the young stems and the leaves the black rot fungus produces small, brow-colored spots, often containing the pycnidial pustules of the fungus. (Figure 2.) The damage to the leaves and shoots is possibly quite slight but its occurrence upon them should not be neglected. These dead, brown spots in the leaves are an unfailing indication of the presence of the black rot in the vineyard and mark unerringly the need for treatment to save the fruit. Black rot attacks the fruit when it is yet very small, causing wholesale destruction of the berries while no larger than medium sized shot. The grape crop may be utterly lost at this stage from black rot by omitting what was this season the fourth spraying (but is ordinarily the third spraying,) in the experiments described on pages 96—102.

Upon the green fruit until more than half-grown, the black rot fungus causes small, dark, sunken areas in which may be seen with a magnifying glass the pin-head pustules characteristic of that stage of the fungus and of the same character as the similar spots in the dead areas of the leaves and young stems. Black rot usually ceases its destructive spread by the midseason and for this reason a limited number of spray treatments are often successful; but in no case may success be expected if the treatments just before and just after blossoming be omitted. Upon the omission of that just before the blossoming period consult page 101.

White Rot, or Ripe Rot, is the second very destructive fungous disease with which the grape grower must now contend in Ohio. The fungus in question has not been fully studied although many examinations of specimens have been made; it is referred to that of white rot (*Coniothyrium Diplodiella* (Speg.) Sacc.) (Scribner, An. Rept. U. S. Dept. Agriculture, 1887, pp. 325-6 and Fungus Diseases of the Grape, etc., pp. 41-44.) Scribner mentions this as having been discovered in Italy in 1878, in France in 1885 and in southwestern Missouri and in neighboring parts of Indian Territory in 1887. Scribner, in the paper just named, refers to the probable efficiency of Bordeaux mixture for the white rot.

Owing either to limited distribution of the fungus or to the lack of field recognition what is here referred to as white rot comes to us without well demonstrated treatment for its prevention. It begins as small. brown colored, rotted spots in the grape, usually after the middle of June, finally involving the whole grape and showing somewhat darker colored pustules in the rotted area. The whole grape when rotted, is at first of a light brown color; subsequently as the rotted grape dries up the pus-

Fig. 1. Cluster of grapes attacked by anthracnose causing bird's-eye rot.

Figure 3. Cluster of grapes attacked by white rot; the rotted grapes have shriveled in drying.

Figure 2. Leaf and stem of grape attacked by black-rot causing dead areas.

tule spots become whitish in color and somewhat more prominent. (Figure 3.)

June 27th, 1899, this rot became obvious at Geneva, Ohio. It was very bad June 29th, and became still worse July 9 to 12th. At this same point June 23rd, 1900, it was observed on one or two vines on the dwelling-house, and was at its worst in the vineyards August 3-10. The Concord grapes were coloring rapidly August 21, 1900, and picking was begun on early varieties (Moore's Early, etc.,) August 29th; the later varieties September 10th. *In other words this rot almost immediately precedes ripening of the grapes.*

During favorable weather periods this rot spreads quite rapidly and does not seem to yield readily to fungicides. Altogether the four years of continued white rot ravages in Ashtabula county, and slightly shorter periods of destruction in western Cuyahoga and Lorain counties have seriously threatened the grape industry on soils that are at all adapted to other crops or to other purposes.

THE AMOUNT OF ROT INFLUENCED BY SOIL AND VARIETY.

Under this caption we are dealing chiefly with the white rot but much of what is stated may be found to apply to black rot as well. Certain varieties of grapes are apparently much more susceptible to the attacks of the white rot. Of the various varieties grown, such as the Concord, Worden, Moore's Early, Niagara, Salem, Delaware, Catawba, Ive's and Norton's Virginia, we may distinguish tentatively at least three classes. Among those most susceptible to rot the Catawba ranks first, followed by the Niagara, Worden and possibly Norton's Virginia. Among those least readily attacked we may place Moore's Early, Delaware, Salem and Wyandot Red. It seems there is a third group of varieties ranking between these in which we may place the Concord, Ive's and some other varieties. This division is based upon somewhat limited observation and may be locally modified, as between the nonsusceptible and middle classes, by the past history and particular situation of vineyards of certain varieties. For illustration, the Delaware is usually rated high in rot resistance where the Concord may be put rather low, yet there are instances in which the Delaware vineyards rotted as badly or even worse than the Concord but a short distance away on the same sort of soil. Should this form of rot prove as persistent and as general as the black rot it will lead to the abandonment of varieties like the Catawba in some of the grape districts. On the other hand, given the varieties generally planted and there are marked differences on the various soils devoted to grape culture.

It is, of course, to be borne in mind that no comparison can be instituted between different varieties on different soils. What follows has reference to observations made on the same varieties, grown upon different soils and in the same or adjacent vineyards. The tendency of the

gravelly soils and those of a more loamy character is to cause a more vigorous growth and a greater density of foliage as well as a greater length of wood. In general there is a greater tendency to rot on vines with this character of growth. Whether the explanation be in the maturity of the growth or in the shading and higher humidity, or in a constitutional tendency, can scarcely be stated. The writer inclines to attribute influences to each of these factors.

Where the soils are of the hard, white, silty character before described, those usually called hard clay soil, with the shale commonly near the surface, or at a greater depth as the case may be, this rot is much less destructive. The growth of the vines is usually much less and the amount of shade is also less but it would appear that the growth matures sooner and general conditions of greater resistance to fungus attack is found in vines of this character.

THE PROBLEM OF ROT PREVENTION AND ITS DIFFICULTIES.

In the matter of rot prevention we may include both black rot and the other, which we call white rot, and for the districts under discussion I can offer very little encouragement to those who would expect even occasional crops of grapes without spray treatment with fungicides. It is equally true that this spray treatment must accomplish the prevention of both black rot and white rot.

The prevention of black rot is not especially difficult under normal conditions and is very generally attained by only a few spray treatments with Bordeaux mixture; the first spraying as the buds are swelling; a second just before blossoming and the third, after the blossoms drop. This applies to nearly all varieties and to soils of every character.

It is not clear that these treatments, extending from May 10 to June 20-25, can be rated very high in the prevention of white rot, although if these early sprayings are omitted there will commonly be few grapes to save from the white rot. Manifestly a spray treatment which is to be effective against white rot must be repeated at very frequent intervals and with a close watch on general conditions. The principle to follow is to spray before the onslaught of the disease.

Another limit in the use of Bordeaux mixture is stated by the date of the ripening of the grapes, so that ordinary Bordeaux mixture can scarcely be applied with safety after early in July.

While referring to the details given in the experiments on pages 96—102, with results obtained from them, one can readily perceive the approximate aid of the several sprayings and the mixture applied. It does not appear that the standard Bordeaux mixture is less effective than one of greater strength and there is apparently no need for changing the

4 and 4 formula (seventy-five gallon formula*) so long and successfully applied by this Station.

While ammoniacal copper carbonate is apparently as effective and satisfactory as *eau celeste,* there is need for some better fungicide to apply just before the coloring of the grapes; however, if one or two more applications of Bordeaux mixture are made by shortening the intervals it might be that this would prove more effective. In this line the work of next season will be pushed.

There is also room for a trial of Bordeaux mixture made with some other alkali than lime, say with caustic soda of commercial grade, after the manner of that used by Halsted in various spraying experiments in New Jersey. (Report of New Jersey Experiment Station 1896.)

From Halsted's results one infers that soda Bordeaux mixture is equally as effective as the standard Bordeaux mixture. One would hope that it would prove less adhesive than standard Bordeaux while rather more actively effective than the *eau celeste* and ammoniacal copper carbonate. The prospects for a rot prevention appear to lie in the lines just indicated.

THE FUTURE OF OHIO GRAPE GROWING.

This topic is considered in respect to the problem of rot prevention in relation to that of market price. One may anticipate good prospects, for grape growing on a small scale near home by reason of those conditions heretofore discussed, since in these scattered localities the matter of rot prevention has proved much less serious; but in grape growing districts the future is scarcely encouraging though it is well worth while to continue to work on spraying for that is the chief hope of a favorable outcome. But the spraying must be done with great thoroughness and careful attention to details in order to succeed. It would appear that power or traction appliances, which will admit of frequent stopping of the spray cart, as well as the use of long hose, at least 25 feet, will lead to more thorough work than present practices. The nozzle must throw a fine spray secured by pressure from the pump, and the spray must be directed to cover all parts properly.

With the modifications of spraying treatment above indicated we may hope for very satisfactory results under average conditions. By average conditions is meant with the fairly resistant varieties, such as the Concord, upon soils really adapted to grape culture. It may prove impracticable to endeavor to save the grapes upon fertile soils where growth is luxuriant, and likewise of doubtful profit to grow varieties ranking as highly susceptible to rot.

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*The original formula of 6 pounds of copper sulfate to 50 gallons was called by Fairchild, "the fifty gallon formula"; that of 4 pounds to 50 gallons, therefore the seventy-five gallon formula, because 75 gallons of mixture are required to contain 6 pounds of copper sulfate.

The future is in the hands of the vineyardists and it certainly encourages no half-way efforts. It would seem wiser to remove the grapes from soils favorable to rot than to continue a losing battle; however, I am not yet convinced that the battle is to be a losing one on the typical grape soils of Ohio. It is certainly to be recommended that vineyards either be cared for, or be removed, since neglected vineyards are a source of infection to those who would endeavor to save their grapes from rot and other troubles.

II. EXPERIMENTS IN THE PREVENTION OF GRAPE ROT.

BY A. D. SELBY AND J. F. HICKS.

In July, 1899, Mr. F. D. Wilson, of Geneva, Ashtabula county, called attention to the destructive prevalence of rot in grapes on his premises and in the vicinity. The Station Botanist visited the region early in August of that year and found conditions as represented. But little spraying had been done in the vicinity and much that had been undertaken was of a desultory character. The losses from rot were very heavy throughout the immediate region, and in the absence of definite results from treatment it was deemed advisable to undertake experiments in 1900, if feasible.

Arrangements were accordingly made early the present season for spraying experiments on a leased vineyard of four acres of the Concord variety, adjoining the premises of Mr. Wilson, and under lease by him. The experiments, to be described hereafter, were conducted in co-operation with Mr. Wilson, upon this "Brakeman" tract, the spraying operations being under the immediate direction of Mr. J. F. Hicks, Assistant Botanist of the Station. In addition to the completed experiments on the Brakeman tract, however, a plan intended to develop similar results was followed upon the vineyard of Mr. Wilson, consisting of mixed varieties of grapes. Brief references will be found to this part of the work, although very little benefit was realized from the treatment of the Wilson vineyard. The work was based upon results obtained by the Station Horticulturist on the Station vineyard, and somewhat with reference to the local work on the vineyards and on other plants. The experiments of this Station many years ago having demonstrated the superiority of Bordeaux mixture, where it can be used, over Eau Celeste and other copper compounds, as well as the equal efficiency of the 4 pound strength of this mixture, 75 gallon formula, it was deemed best to use Bordeaux mixture of this strength, 4 pounds of copper sulfate and 4 pounds of lime

to 50 gallons of water as the standard fungicide, so long as possible. Stronger Bordeaux mixture of 6 pound and 8 pound strengths, respectively, to 50 gallons of water, were also included, as were spray solutions of formalin (40 percent formaldehyde,) salicylate of soda and salicylic acid with lime. Winter treatment was made, while for certain rows otherwise subjected to the same treatment one each of the various strengths was omitted. This series of omissions furnishes some valuable information. It is hoped that the diagram annexed will give a sufficiently clear and concise statement of the various sprayings given the several portions of the vineyard.

(Diagram.)

TABLE I. SUMMARY OF SPRAYINGS ON BRAKEMAN VINEYARD.

(Beginning at South s de.)

Row	1	Sprayed.	eight times	On 1 & 2 Bordeaux 6 lbs. copper sulfate.
"	2	"	" "	
"	3	"	" "	Stronger Bordeaux first spraying only
"	4	"	" "	
"	5	"	" "	
"	6	"	" "	
"	7	"	" "	East one-fifth, seventh spraying omitted.
"	8	"	" "	
"	9	"	" "	Bordeaux mixture for sixth spraying.
"	10	"	" "	
"	11	"	seven times—Omitted fourth spraying.	
"	12	"	eight times.	
"	13	"	seven times—Omitted third spraying.	
"	14	"	eight times.	
"	15	"	seven times—Omitted second spraying.	
"	16	"	eight times.	
"	17	"	eight times	Copper sulfate solution on these for first and second spraying, East one-third No. 18 omitted second spraying.
"	18	"	" "	
"	19	"	" "	
"	20	"	eight times using only Formalin, 1 lb. to 20 gallons.	
"	21	"	eight times	West ½ salicylic acid ¼ lb. lime 2 lbs. to 10 gallons water. East ½ salicylate soda, ¼ pound to 10 gals. water.
"	22	"	seven times—Omitted first spraying.	
"	23	Unsprayed.		

Unless otherwise stated, sprayings first to fifth inclusive were of Bordeaux mixture I of spray calendar, 4 lbs. copper sulfate, 4 lbs. lime to 50 gallons. Sprayings sixth to eighth were with ammoniacal copper carbonate as per calendar..

DATES OF SPRAYINGS.

First—April 18.
Second—May 10.
Third—May 28.
Fourth—June 22 and 23.
Fifth—July 2 and 3.
Sixth—July 12, (with am. copper carb.)
Seventh—July 27.
Eighth—August 14 and 15.

The vineyard is 46 rods long and consists of 23 rows 10 feet apart, extending east and west. The soil is gravelly, the area sloping very gently to the west with lowest land in northwest corner. Other inequalities of elevation are slight. The grapes were pruned to three canes and tied; the whole being put in good order. The old rotted grapes were gathered from vines, wires, etc., during the early part of the spring. There was a very good promise of buds; but a freeze on May 11th, just as the buds were beginning to open, injured the prospect very greatly, and somewhat unevenly. The areas of greater injury were toward the south side.

The spraying in the work was done, except for the first application, by means of a Morrill & Morley pump, mounted on a 50 gallon barrel, and connecting with two 25 foot lines of hose, each carrying a double Vermorel nozzle. One person manipulated the pump and one was at each line of hose. The first application was made with a traction pump and short hose, admitting of only approximate thoroughness. For the applications after the first, thoroughness was attained by frequent stopping and spraying until the vines, posts, etc., were dripping; during the earlier sprayings attention was given to covering the fallen, rotted grapes with the spray. The following table shows the area sprayed, amount of mixture used, and time consumed for the whole area receiving copper compounds, as well as those several items computed per acre. Attention is called to the use of almost 150 gallons of mixture per acre (average 2.9 barrels of 50 gallons each) for each of the five later applications. The details are shown in the table itself.

TABLE II.—SUMMARY OF TIME AND MATERIALS CONSUMED ON AREA SPRAYED WITH BORDEAUX MIXTURE AND COPPER CARBONATE; ALSO STATEMENT OF TIME AND AMOUNTS PER ACRE SPRAYED WITH SAME.

Spraying and Date.	Total area sprayed acres.	Hours for crew.	Barrels of mixture each 50 gallons.	Pounds copper sulfate or copper carbonate.	Acres sprayed per hour.	Hours per Acre.	Barrels of mixture per acre.
First, April 18, 1900	....	....	....	....	....	....	....
Second, May 10, 1900	3.3	10	6⅓	27⅓	.33	3.0	1.9
Third, May 28, 1900	3.3	10½	6½	28	.31	3.2	1.97
Fourth, June 22–3, 1900	3.3	10	9½	40	.33	3.0	2.9
Fifth, July 2–3, 1900	3.3	11	10	42	.30	3.3	3.0
Sixth, July 12, 1900	3.4	10	10	3.6	.34	2.9	2.9
Seventh, July 27, 1900	3.4	10	10	3.7	.34	2.9	2.9
Eighth, August 14, 1900	3.4	11	10	3.7	.31	3.2	2.9

In general, with help accustomed to the work and with the conveniences not very marked, one barrel or 50 gallons of mixture may be applied per hour or 10 barrels per day.

From this table we may arrive at the cost per acre of the several applications from the 2nd to the 8th, inclusive. This appears to have been as follows:—

COST OF VINEYARD SPRAYING PER ACRE.

Time for crew, 3 hours per acre, 7 sprayings 21 hours at 35 cents per hour......	$7 35
10 barrels of Bordeaux mixture, 4 sprayings at 25 cents per barrel..................	2 50
7.7 barrels Am. Cop. Carbonate at 20 cents per barrel, three sprayings...........	1 54
	$11 39

These figures may be somewhat reduced with better conveniences, such as larger spray tank, more convenient water supply, and working on a more extensive scale. The reduction will consist, for thorough work, more largely in reduction of the labor item; the amount of mixture stated is very near to the necessities for thorough work.

The black rot appeared at the usual period, destroying nearly the whole crop on Rows 13 and 23; there was also an apparent lack of efficiency of the salicylate of soda and salicylic acid-lime solutions to protect satisfactorily from black rot. Row 13, which received all the sprayings except the third, made May 28th, just previous to the blossoming of the grapes, fared but slightly better than the unsprayed row. The first white rot was observed in the vineyard about June 25th, it was very destructive August 3rd to 12th. Clusters freed from rotted grapes and dipped in the ammoniacal copper carbonate solution employed for spraying purposes, suffered about as much from rot as those receiving only the sprays applied. During the time of most disastrous rotting the weather was hot and "steamy." The crop was gathered and marketed in small quantities, being put up in four pound baskets. The following table gives the yields of the several rows both in four pound baskets and in pounds of wine grapes subsequently gathered. We are under obligations to Mr. Wilson for this part of the record:—

TABLE III.—YIELD OF GRAPES FROM THE BRAKEMAN VINEYARD.

No. of Row.	Pounds of wine grapes sold.	Baskets of 4 lbs. each, marketable grapes.	Remarks.
1	10	101	Bordeaux mixture of greater strength on rows 1 & 2.
2	20	93	
3	30	83	See Table I.
4	20	73	
5	30	80	Standard.
6	45	98	Standard.
7	45	85	15 baskets, East one-fifth.
8	70	87	Standard.
9	55	69	No apparent advantage from use of Bordeaux mixture for sixth spraying.
10	40	104	Standard.
11	65	100	Spray omitted just after blooming.
12	45	102	Standard.
13	121	10	Spray omitted on new shoots.
14	56	104	Standard.
15	42	102	Spray omitted on opening buds.
16	73	102	Standard.
17	62	99	Copper sulfate on rows 17, 18 and 19, apparently not more efficient than Bordeaux mixture.
18	63	84	
19	46	47	
20	11	....	Formalin solution a failure.
21	15	....	Salicylic acid and compounds a failure.
22	60	62	Bordeaux mixture and cop. carbonate on this row.
23	....	....	Unsprayed.

Rows 1 to 8, inclusive, show a slightly lower yield in baskets than Rows 10 to 12 and 14 to 18, inclusive. Row 19 indicates, possibly, the proximity of a badly rotted row, although Row 22 in a more unfavorable situation has a slightly better yield. The ragged clusters of No. 13 are indicated in the increased amount of wine grapes. Row 13 certainly teaches the efficacy of the spraying which should be made immediately preceding the blossoming of the grapes, on the new shoots of the vine. Row 9, which received Bordeaux mixture for sixth application instead of ammoniacal copper carbonate, yields unfavorable results. No sufficient explanation is at hand. There was different pruning given a portion of Row 1, so that the slightly increased yields of Rows 1 and 2 do not indicate a decidedly increased efficiency for the stronger Bordeaux mixture. No difference whatever was observed as between this strength and twice the usual formula in the Wilson tract, where most of the crop rotted despite the spraying made at about the same periods as those detailed for the brakeman tract.

On Row 22 the first spraying was omitted; on Row 15, the second; on Row 11 the fourth spraying was likewise omitted. The results fail to indicate loss therefrom, although there might have been some equalizing of the possibly more scattered clusters on Row 11 by the white rot. This rot spreads rapidly in dense clusters. Formalin, salicylate of soda and

salicylic acid with lime are of about equal value in spraying and show a total loss of grapes, marketable in baskets.

The maximum results of the spraying, as represented by Rows 10, 11, 12, 14, 15, 16, 17 and 18, indicate that 50 percent of the possible crop was saved by the treatment, as the yield upon these represent about one-fourth a crop. The estimated loss from white rot on this same area is placed at about the same amount.

RESULTS OF OTHER SPRAYING OPERATIONS IN THE SAME REGION.

Extensive spraying of grapes during the season was carried on by Mr. E. N. Warner, Unionville, and on the "Highland Farm," next Mr. Warner's, which is directed by Mr. O. M. Stafford, of Cleveland, with Mr. Clayton H. Goodrich as Manager.

Mr. Warner applied the spray to about 40 acres and gathered a yield of 18,000 baskets of 8 lbs. each, and 28,000 of 4 lbs. each, or by combination say 32,000 eight pound baskets against 15,000 baskets in 1899. He estimates a good yield at 40,000 baskets of 8 lbs. size; also that without spraying he should have gathered no grapes in 1900. This last statement is supported by the experience of those who did not spray. A neighbor, Mr. Dilley, for whom Mr. Warner did spraying, had a yield of 3,000 baskets against 300 in 1899.

From the Highland Farm vineyards of 80 acres no grapes were picked in 1899. In 1900, the yield amounted to 18,000 baskets of 8 lbs. each, chiefly from about half the area. In these instances, as indeed in the common practice at present, traction sprayers were used, kept constantly moving forward and with men to direct the nozzles. The amount of mixture required by spraying in this manner is very much less than by thorough drenching of the vines. It would appear that Mr. Warner's vineyards are more favorably situated to resist rot than those of Highland Farm; indeed, certain areas belonging to Mr. Warner suffered severely, while others were almost entirely saved. Mr. Thos. Reed of Harpersfield has been spraying for some years but suffered considerable losses; his experience is in line with that on Highland Farm. In an article published in the Geneva, Ohio, "Free Press" of October 13, 1900, Mr. Warner expresses the opinion that the grape rot may be eradicated by continued spraying during about three years. Were all results as favorable as those of Mr. Warner himself, so hopeful a view might properly be entertained. As the results now stand, however, we should be prepared to continue the battle somewhat longer. With thorough treatment on favorable soils, a profitable saving of the grape crop may certainly be attained by spraying.

SUMMARY.

In the first portion of this bulletin the serious losses from grape rots, more especially from what is herein referred to as white rot (*Coniothyrium Diplodiella*) are considered.

These losses threaten the grape industry in much of the grape belt skirting Lake Erie.

Certain varities of grapes, such as Catawba, Niagara, Salem, etc., are others, are very susceptible to the attacks of this rot.

Other varieties, such as Moore's Early, Delaware, Salem, etc., are much more resistant to the rot, while the Concord variety occupies a somewhat intermediate position in this regard.

With like varieties a decided difference has been observed in the amount of rot in different soils; the hard, whitish silts, commonly known as clay soils, are much less favorable to rot than gravelly soils or others of higher fertility.

In the spraying experiments described in the second part of this bulletin careful treatment was applied upon a vineyard of about four acres of the Concord variety, situated near Geneva, Ashtabula county, Ohio.

The unsprayed portion yielded no marketable grapes for table use; likewise those portions treated with formalin, salicylate of soda and salicylic acid with lime. Unsprayed vineyards of the region showed like results. The most favorable results were obtained from eight applications of fungicides, including five of Bordeaux mixture and three of ammoniacal copper carbonate. Of these, two applications of Bordeaux mixture were made before the unfolding of the buds.

The omission of the spray upon the young shoots just before blossoming showed as a result a loss of 90 percent from black rot. Omissions of the earlier, or of the next later spraying, showed no decided losses.

The total beneficial result on this vineyard from the spraying already summarized was a saving of 50 percent of the possible marketable crop. Upon more favorable soils better results were obtained by private parties.

Upon the typical grape soils, and with moderately resistant varieties, such as the Concord, profitable results from spraying rot-infected vineyards seven to nine times with standard fungicides, are indicated by these and other experiments.

The standard strength of Bordeaux mixture (4 pounds of copper sulfate and 4 pounds of lime to 50 gallons of water) has proved equally as efficient as greater strengths. Slightly shorter intervals than two weeks between the sprayings are recommended after June 20th.

Almost total loss of the grape crop upon unsprayed vineyards in rot infected districts is predicated from the observations of the last two seasons.

CALENDAR OF STRIKING DATES IN GRAPE CULTURE FOR GENEVA—UNIONVILLE DISTRICT, 1899 AND 1900.

Operations.	1899.	1900.
Grape buds unfolding	About May 8	May 10.
First spraying of Spray Calendar, second of these experiments		May 8–10.
Frost injury	Slight, May 22	" 11.
New shoots ½ feet long	May 27	" 28.
Second spraying (third this experiment)		" 28.
Grapes blossoming		June 11.
Grapes out of blossom		" 21.
Black rot prevalent		" 15–22.
Third spraying (fourth this experiment)		" 22–23.
First observed white rot	June 27–29	" 25.
Fourth spraying (fifth this experiment)		July 2 and 3.
Fifth spraying (sixth this experiment)		July 12.
Sixth spraying (seventh this experiment)		" 27.
Rot disastrously prevalent	July 9–12	Aug. 3–10.
Seventh spraying (eighth this experiment)		" 14–15.
Concords coloring		" 21.
Began picking early sorts		" 29–Sept 1
" " concords		Sept. 10.
Completed picking concords		Oct. 20.

PUBLICATIONS OF THE OHIO AGRICULTURAL EXPERIMENT STATION.

A complete list of previous publications of this Station may be found in Bulletin 120. Following are the titles of subsequent bulletins:

No. 121. A condensed handbook of the diseases of cultivated plants in Ohio.

No. 122. Onion Smut—Preliminary experiments.

No. 123. Grape rots in Ohio.

Ohio Agricultural Experiment Station.

BULLETIN 124

WOOSTER, OHIO, MARCH, 1901.

THE MAINTENANCE OF FERTILITY.

FIELD EXPERIMENTS WITH FERTILIZERS ON CORN, OATS AND WHEAT IN 1899 AND 1900.

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The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 126 MARCH, 1901.

SUGAR BEET INVESTIGATIONS IN OHIO, IN 1900.

BY A. D. SELBY AND J. W. AMES.

Through the continued cooperation of the United States Department of Agriculture, sugar beet seed was distributed to Ohio growers again in 1900. About 900 pounds was supplied by the Department of Agriculture through the Section of Seed and Plant Introduction of the Division of Botany. This seed was imported from Europe for use in the several portions of the country and came from the four growers listed below, Numbers 3941, 3942, 3943, 3944 and 4416. About 100 pounds of sugar beet seed was contributed by F. O. Boyd & Co., New York City. This was from the European grower, Licht; it appears as No. 1900. Some 50 pounds of seed from the Department of Agriculture originally sent to the Bücher & Gibbs Plow Co., of Canton, O., was forwarded to this Station and distributed to the various applicants. The total amount of seed, about 1,050 pounds, was distributed chiefly in March to 203 applicants located in 60 counties of Ohio. As to section, 107 of these recipients were in the northern, 57 in the middle and 39 in the southern section of the state. Early planting of the seed was strongly urged. The cultural directions were the same as in preceding years.

VARIETIES OF SEED AND GERMINATING QUALITY.

The numbers of the four principal varieties are those of the Section of Seed and Plant Introduction of the Division of Botany.

The number 1900 is a record number of this Station.

No. 3941. White Improved Sugar Beet Vilmorin.
No. 3942. Zehringen Klein Wanzlebener Sugar Beet, Strandes.
No. 3943. Russian Grown Klein Wanzlebener Sugar Beet, Mrozinski.
No. 4416. Russian Grown Klein Wanzlebener Sugar Beet, Mrozinski.
No. 3944. German Grown Klein Wanzlebener Elite Sugar Beet, Dippé.
No. 1900. Improved Klein Wanzlebener Sugar Beet, Licht.

The several principal sorts of beet seed were tested by Mr. J. F. Hicks, Assistant Botanist, with the following result:

TABLE I: RESULTS OF GERMINATION TESTS OF SUGAR BEET SEED IN 1900.

	No. 3941 White Improved (Vilmorin.)	No. 3942 Zehringen (Strandes.)	No. 3943 Klein Wanz-lebener (Mrozinski.)	No. 3944 Klein Wanz-lebener (Dippé.)
Number seed balls planted.	100	100	100	100
Number sprouts end of 5 days	9	43	....	56
" " " 6 "	55	84	....	128
" " " 7 "	100	97	....	168
" " " 9 "	106	109	....	173
" " " 11 "	113	122	....	188
" " " 14 "	113	122	about 200	188
Number seed balls germinated	58	52	*87	82
Number with 4 or more sprouts	5	7	....	8
" " 3 sprouts	7	4	....	14
" " 2 "	22	32	....	44
" " 1 "	24	52	....	82

The results of the seed tests are rather more satisfactory than those of 1899. In no case was there any serious complaint of the germination of the beet seed. In our own plots here at the Station all seed sown gave a satisfactory stand; the Russian seed Nos. 3943 and 4416, was apparently the best of all in this regard. The stand of beets generally secured was superior to previous years.

THE SEASON'S WEATHER CONDITIONS.

The weather conditions were favorable to a good stand of beets and the midseason to a vigorous growth of weeds as well as beets. The temperatures for the growing season have generally been above normal, conspicuously so during August, September and October.

* Unfortunately all other records than this "number of seed balls germinated 87" for sample No. 3943 were mislaid.

The following table is compiled from the Ohio Weather Bureau Reports:

TABLE II: METEOROLOGICAL SUMMARY FOR 1900.

Month.	Rainfall—northern section, inches.		Rainfall—entire state, inches.		Temperatures, entire state. Degrees Fahrenheit.	
	1900.	Normal.	1900.	Normal.	Average 1900.	Normal average.
'anuary	1.98	2.64	2.37	2.95	31.1	28.0
February	3.84	2.63	3.53	2.88	26.0	28.4
March	2 20	2.98	2.35	3.42	32.9	38.4
April	2.13	2.69	1.89	2.90	50.1	49.6
May	2.23	3.74	2.40	3.47	62.9	61.0
une	3.00	3.32	2.99	3.41	69.8	70.3
July	5.53	3.70	4.62	3.89	74.1	73.7
August	3.52	2.57	3.68	2.91	76.3	71.3
September	1.89	2.80	1.76	2.64	69.3	65.6
October	2.03	2.35	1.89	2.11	60.5	52.5
November	3.63	3.33	4.15	3.29	41.6	40.4

It seems quite probable that the number of clear days, or better still, perhaps, the total sunshine during the critical periods has very great direct influence, other factors being constant, upon the processes of the plant by which sugar is elaborated. In a certain view temperature and rainfall may be considered indicative of these other matters as well.

TABLE III: CLIMATOLOGICAL DATA FOR FOUR STATIONS IN THE SUGAR BEET DISTRICT DURING FOUR MONTHS OF 1897, 1898, 1899 AND 1900.*

	Napoleon, Henry Co.				Rocky Ridge, Ottawa Co.				Tiffin, Seneca Co.				Vickery, Sandusky Co.				Averages.			
	'97	'98	'99	'00	'97	'98	'99	'00	'97	'98	'99	'00	'97	'98	'99	'00	1897.	1898.	1899.	1900.
JULY.																				
No. Days—																				
Rainy	10	7	7	7	8	7	8	10	10	9	12	14	18	9	9	14	10.25	8.	9.	11.25
Clear	20	19	19	20	11	10	14	9	18	23	21	16	11	18	14	7	15.	18.5	17.0	18.0
Partly Cloudy	2	8	7	7	11	7	10	17	11	6	7	12	15	14	11	19	9.75	8.75	8.75	18.75
Cloudy	9	4	5	4	9	5	7	5	2	1	3	3	5	4	6	5	6.25	3.5	5.25	4.25
AUGUST.																				
No. Days—																				
Rainy	9	6	1	6	11	10	2	9	12	10	8	10	12	10	4	12	11.2	9.1	2.5	9.25
Clear	13	20	25	20	10	12	21	14	18	21	29	21	10	13	19	12	12.75	16.5	24.25	16.75
Partly Cloudy	12	4	4	7	13	10	6	10	9	8	1	10	14	14	8	14	12.	9.0	4.75	10.25
Cloudy	6	7	2	4	8	9	4	7	4	2	1	0	7	4	4	5	6 25	5.5	2.75	4.00
SEPTEMBER.																				
No. Days—																				
Rainy	2	9	4	3	2	8	10	5	2	12	10	5	2	8	6	6	2.0	9.25	7.5	4.75
Clear	27	15	13	25	20	17	14	16	27	20	19	22	17	19	11	16	22.75	17.75	14.	19.75
Partly Cloudy	2	7	9	1	8	6	5	8	2	8	5	6	11	5	11	8	5.75	6.5	7.5	5.75
Cloudy	1	8	3	4	2	7	11	6	1	2	7	2	2	6	8	6	1.5	5.75	8.5	4.5
OCTOBER.																				
No. Days—																				
Rainy	2	5	6	5	4	8	7	3	3	13	7	6	3	1	9	3	3.0	4.25	7.25	4.25
Clear	14	6	21	24	19	4	18	17	22	12	21	21	11	10	12	17	16.5	8.0	18.0	19.75
Partly Cloudy	12	12	2	0	3	12	5	7	6	7	4	8	15	11	11	9	9.0	10.5	5.5	6.0
Cloudy	5	13	8	7	9	15	8	7	3	12	6	2	5	10	8	5	5.5	12.5	7.5	5.25

* No account is here taken of days with merely a trace of rainfall.

To present this phase of the question more fully we have herewith included a tabulation of the number of rainy days, clear days, partly cloudy and cloudy days recorded at Napoleon, Henry county; Rocky Ridge, Ottawa county; Tiffin, Seneca county, and Vickery, Sandusky county, during July, August, September and October for the years 1897, 1898, 1899 and 1900. We are under obligations to J. Warren Smith, Section Director of the Weather Bureau, for his kindness in this connection; the data tabulated will be found in the published reports.

Taking the observations at these four points in the sugar beet belt, their average should give safe results. These show the month of July to vary less than any other during the four-year period. In 1897, the month of September and the first half of October were very favorable to sugar elaboration. That season's beets show very favorably. The season of 1898 may be called "choppy" for all four months; taken as a whole it was unfavorable to sugar content and purity of beets. In 1899 the month of August and the first half of September were characterized by light rainfall and sunshiny weather. The season of 1900 was one of disappointment, although much of September was fine.

Figure 1 is a diagrammatic presentation of the rainfall data for August, September and October, 1897, 1898, 1899 and 1900, showing the amounts and daily distribution as well as the total monthly rainfall for the four months of July, August, September and October of these years. The blank day spaces in this diagram speak commonly for clear weather; from a careful perusal we must conclude that sugar elaboration is a phenomenon of maturity in the beets, and that the season's record of rainfall, especially that of months immediately preceding clear periods, particularly for the month of July, may exercise a powerful influence on the conditions in this regard. The excessive rainfall for July and August, combined, in 1900, together with the distribution of the rains in September and October, may have had a great deal to do with the delayed maturity of the beets in that season. The seasons of 1897 and 1899 were the favorable ones for sugar in the beets, as will be seen from Table VI, page 154.

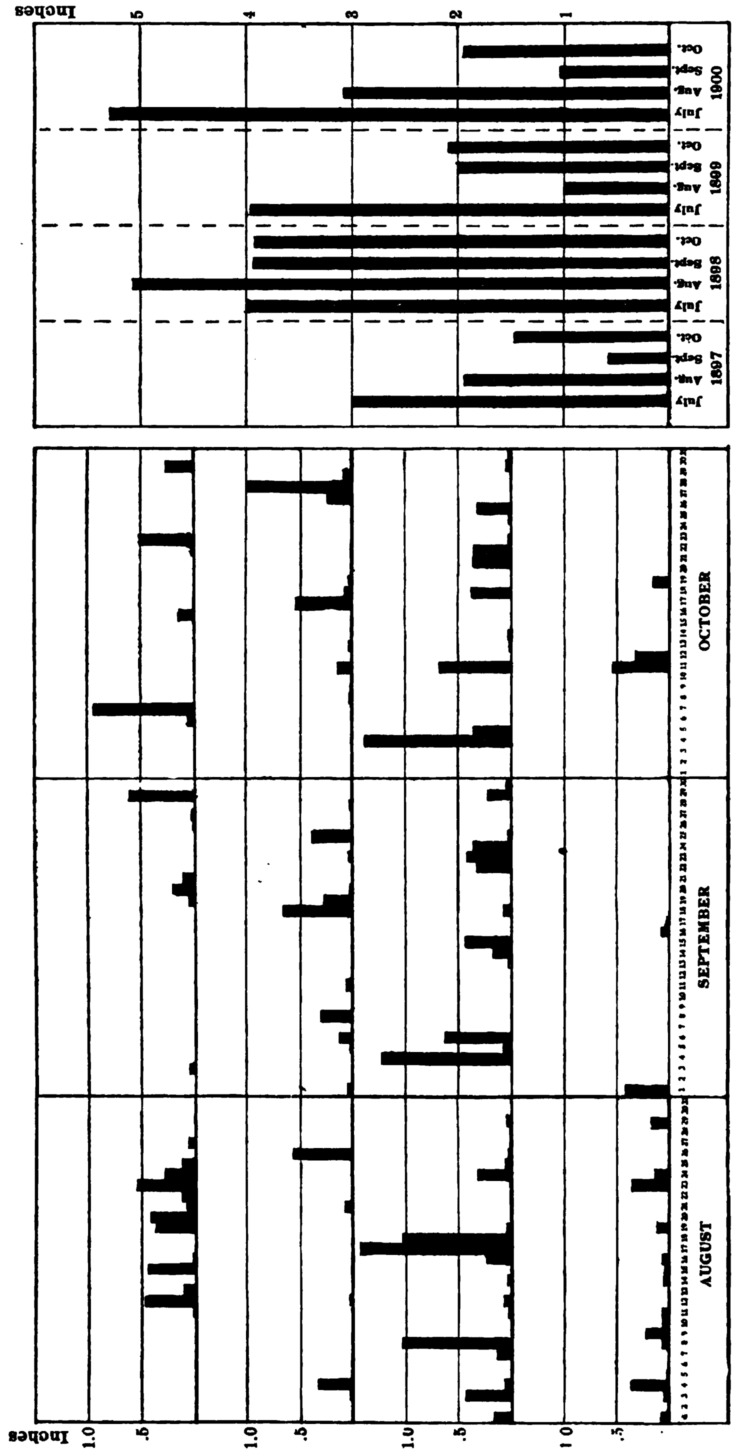

FIGURE 1.—On the left a graphic representation of the average daily rainfall at Napoleon, Rocky Ridge, Tiffin and Vickery, Ohio, during August, September and October of the years 1897, 1898, 1899 and 1900; this average is to represent the climatological variation in the sugar beet district. At the right the total rainfall for the months of July, August, September and October for the same years is graphically represented upon the same scale.

RESULTS OF ANALYSES MADE IN 1900.

Of the 203 persons to whom sugar beet seed was sent, 109 have sent samples of beets for analysis. Of the 303 samples analyzed before the closing of the records in this bulletin, 226 are from the northern section, 57 from the middle section and 20 from the southern. The results of the analyses are set forth in detail in Table IV and summarized in Table V. Table VI compares these results with those of previous years.

TABLE IV: DETAILED RESULTS OF SUGAR BEET

Labor-atory No.	Name of grower.	Postoffice.	County.	Character of soil.	Variety.
2941	D. H. Foss	Ashland	Ashland	Sandy	Zehringen.
2942	"	"	"	"	Rus. Kl. Wanz.
2943	"	"	"	"	White Improv.
2944	"	"	"	"	Ger. Kl. Wanz.
	Average, 4 samples.				
2998	R. L. Dowdell	Bethesda	Belmont	Sandy loam	Klein Wanz.
2852	J. E. Davis	Mechanicsburg	Champaign.	Black loam	Zehringen.
2853	"	"	"	"	Klein Wanz.
2854	"	"	"	"	
2855	"	"	"	"	White Improved.
2856	Jasper Demint	"	"	Clay loam	Rus. Kl. Wanz.
2857	"	"	"	"	Ger. "
2870	Iva Creamer	"	"	"	Rus. "
2872	"	"	"	Sandy loam	White Improved.
2873	"	"	"	"	Zehringen
2874	"	"	"	"	Ger. Kl. Wanz.
2974	John M. Diltz	"	"	Clay	"
2975	"	"	"	"	"
3084	Elmer Diltz	Cable	"	"	Rus. Kl. Wanz.
3085	"	"	"	"	Ger. Kl. Wanz.
	Average, 14 samples.				
2898	D. H. Snavely	Springfield	Clark	Mixed clay	Kl. Wanz.
2928	O. M. Trumbo	Donnelsville	"	Gravel loam	Imp. Vilmorin.
2929	"	"	"	"	Rus. Kl. Wanz.
2930	"	"	"	"	Ger. "
2931	"	"	"	"	Zehringen
3073	A. E. Humphreys	Mad River	"	Black loam	Rus. Kl. Wanz.
3074	"	"	"	"	Zehringen.
3075	"	"	"	"	Imp. Vilmorin.
3076	"	"	"	"	Kl. Wanz.
	Average, 9 samples.				
2858	John Wagoner	Coshocton	Coshocton.	Clay loam	Kl. Wanz.
2970	S. G. Leavitt	Keene	"	Clay subsoil	Rus. Kl. Wanz.
2971	"	"	"	Clay loam	Ger. "
2979	Jacob Siegrist	Wills Creek	"	Sandy loam	
3019	John T. Haxton	Mound	"	Clay loam	Ger. Kl. Wanz.
3020	"	"	"	"	Rus. "
3042	J. L. Sicker	Bacon	"	"	" "
3043	Adam Royer	Wills Creek	"	Sand loam	" "
	Average, 8 samples.				
2958	W. Bradley	Strongsville	Cuyahoga	White	Ger. Kl. Wanz.
2959	"	"	"	"	Rus. "
3049	Jacob Pletscher	Berea	"	Yellow clay	" "
3050	"	"	"	"	" "
3051	"	"	"	"	White Improved.
3052	"	"	"	"	Zehringen.
	Average, 6 samples.				
2977	H. Scudder	New Weston	Darke	Sandy	Kl. Wanz.
2978	"	"	"	"	"
3026	Loyal G. Rhotehamel	Greenville	"	Sandy loam	Vilmorin.
3027	" "	"	"	"	Ger. Kl. Wanz.
3028	" "	"	"	"	Zehringen.
3029	" "	"	"	"	Rus. Kl. Wanz.
	Average, 6 samples.				
2996	Chas. Parker	Defiance	Defiance	Black sand	Imp. White.
2997	"	"	"	"	Zehringen.
	Average, 2 samples.				
2848	Edw. W. Kinnel	Delaware	Delaware	Black loam	Zehringen.
2849	"	"	"	"	Ger. Kl. Wanz.
2850	"	"	"	"	Imp. White.
2851	"	"	"	"	Rus. Kl. Wanz.
	Average, 4 samples.				

INVESTIGATIONS IN OHIO FOR 1900.

Date of planting.		Width between rows—inches.	Date of sampling.		Date of analysis.		Average weight of beets—ozs.	Sucrose in beets—per cent.	Purity co efficient.	Laboratory No.
May	2	20	Oct.	29	Nov.	3	11.8	10.9	80.4	2941
"	2	20	"	29	"	3	9.8	11.1	79.5	2942
"	2	20	"	29	"	3	10.	10.1	76.3	2943
"	2	20	"	29	"	3	9.8	10.9	77.8	2944
							10.3	10.7	78.5	
April	5	24	Oct.	25	Nov.	6	6.2	14.3	83.	2998
April	12	22	Oct.	19	Oct.	22	23.7	10.9	78.2	2852
"	12	22	"	20	"	22	14.9	10.6	79.4	2853
"	12	22	"	20	"	22	25.7	11.5	81.7	2854
"	12	22	"	20	"	22	25.1	11.1	82.4	2855
March	26	16	"	20	"	22	21.6	11.2	83.1	2856
"	26	16	"	20	"	22	19.2	12.	83.4	2857
"	31	18	"	22	"	23	14.3	11.5	78.7	2871
"	31	18	"	22	"	23	17.7	10.6	78.3	2872
"	31	18	"	22	"	23	15.5	11.8	78.5	2873
"	31	18	"	22	"	23	21.2	8.6	73.4	2874
May	1	30	"	31	Nov.	3	4.5	12.4	80.2	2974
"	1	30	"	31	"	3	4.7	13.3	81.4	2975
"	7	30	....	....	"	17	11.3	11.9	76.7	3084
"	7	30	....	....	"	17	8.2	13.8	78.4	3085
							16.2	11.5	79.5	
May	19	20	Oct.	23	Oct.	23	9.9	9.4	74.4	2893
April	19	20	"	25	"	29	19.5	8.5	74.4	2928
"	19	20	"	25	"	29	9.	8.3	66.9	2929
"	19	20	"	25	"	29	14.	10.4	81.5	2930
"	19	20	"	25	"	29	11.7	10.2	79.8	2931
"	20	20	Nov.	10	Nov.	13	17.1	9.1	74.	3073
"	20	20	"	10	"	13	16.1	9.8	82.1	3074
"	20	20	"	10	"	13	16.5	9.	76.4	3075
"	20	20	"	10	"	13	17.3	10.5	83.4	3076
							13.4	9.4	76.9	
May	8	20	Oct.	9	Oct.	22	40.3	13.9	82.5	2858
April		16	"	30	Nov.	3	7.1	7.7	64.3	2970
"		16	"	30	"	3	8.3	5.8	59.2	2971
May	1	20	"	30	"	3	15.3	12.3	80.7	2979
"	1	15	Nov.	2	"	6	15.2	10.1	73.1	3019
"	1	15	"	2	"	6	18.7	7.8	68.3	3020
"	10	24	"	6	"	8	25.	11.	78.9	3042
"	15	18	"	8	"	8	37.3	11.4	83.9	3045
							20.9	10.0	73.8	
May	17	19	Oct.	29	Nov.	3	7.7	11.	76.8	2958
"	17	19	"	29	"	3	4.2	10.8	75.5	2959
April	20	14	Nov.	6	"	9	8.	12.3	81.5	3049
"	20	14	"	6	"	9	5.8	14.9	83.9	3050
"	20	14	"	7	"	9	8.4	13.5	82.5	3051
"	20	14	"	7	"	9	9.6	12.	77.8	3052
							7.8	12.4	79.6	
May	22	26	Oct.	29	Nov.	3	8.6	9.9	73.6	2977
"	22	26	"	29	"	3	9.2	8.9	73.6	2978
April	23	18	Nov.	5	"	6	8.	11.9	83.2	3026
"	23	18	"	5	"	6	14.3	10.	81.3	3027
"	23	18	"	5	"	6	5.5	12.5	81.6	3028
"	23	18	"	5	"	6	4.6	8.1	76.6	3029
							8.4	10.2	78.8	
April	27	20	Nov.	2	Nov.	6	6.8	13.	84.	2996
"	27	20	"	2	"	6	4.1	14.8	83.9	2997
							5.4	13.9	83.9	
April	10	6	Oct.	20	Oct.	22	24.4	10.5	77.6	2848
"	10	6	"	20	"	22	28.8	9.4	76.1	2849
"	10	6	"	20	"	22	26.	9.5	76.9	2850
"	10	6	"	20	"	22	21.	10.9	81.4	2851
							25.0	10.0	78.0	

TABLE IV: DETAILED RESULTS OF SUGAR BEET

Labor-atory. No.	Name of grower.	Postoffice.	County.	Character of soil.	Variety.
2877	Isaac L. Sollars	Rattlesnake	Fayette	Black loam	Zehringen.
2878	"	"	"	"	Kl. Wanz.
	Average, 2 samples.				
3057	Samuel Taylor	Grove City	Franklin	Black loam	Vilmorin.
3058	"	"	"	"	Kl. Wanz.
	Average, 2 samples.				
2899	N. O. Black	Winameg	Fulton	Sand	Zehringen.
2900	"	"	"	"	Kl. Wanz.
2901	"	"	"	"	White Imp.
2902	"	"	"	"	Kl. Wanz.
3080	E. D. Naugle	Delta	"	Black sand	Vilmorin Imp.
	Average, 5 samples.				
2992	Joseph Schoenherr	Fairfield	Greene	Black loam	Zehrengin.
2921	J. A. Cheney	Findlay	Hancock	Black loam	
2863	P. T. Michael	Deshler	Henry	Black loam	Zehringen.
2864	"	"	"	"	Kl. Wanz.
2966	Simon E. Boyer	"	"	"	Vilmorin.
2967	"	"	"	"	Kl. Wanz.
2968	"	"	"	"	Rus. "
2969	"	"	"	"	Zehringen.
2993	James M. Longbrake	"	"	"	White Vilmorin
2994	"	"	"	"	
2995	"	"	"	"	Ger. Kl Wanz.
3034	M. C. Bowers	Westhope	"	"	"
3035	"	"	"	"	"
3043	Geo. P. Pierce	Deshler	"	"	Rus. "
3066	J. B. Osenbaugh	"	"	"	Zehringen.
3067	"	"	"	"	Vilmorin.
3068	"	"	"	"	Ger. Kl. Wanz.
3069	"	"	"	"	Rus. "
	Average, 16 samples				
2859	Wm. Raby	Welcome	Holmes	Clay	Ger. Kl. Wanz
2860	"	"	"	"	White improved
2861	"	"	"	"	Zehringen.
2862	"	"	"	"	Rus. Kl. Wanz
	Average, 4 samples				
2951	D. Coe	Centerburg	Knox		
2952	"	"	"		
	Average, 2 samples.				
3061	W. N. Hulett	Breakman	Lake	Clay	Kl. Wanz.
3062	"	"	"	"	Vilmorin.
3063	"	"	"	"	Zehringen.
3064	"	"	"	"	Kl. Wanz.
	Average, 4 samples.				
3059	Ralph Dyer	Rochester	Lorain	Clay loam	
3060	"	"	"	"	
3072	"	"	"	"	
	Average, 3 samples.				
2879	Edward N. Todd	Neapolis	Lucas	Yellow sand	Ger. Kl. Wanz.
2882	Wm. C. Brossia	E. Toledo	"	Black loam	Rus. "
2883	"	"	"	"	Ger. "
2884	"	"	"	"	Zehringen.
2885	"	"	"	"	White Imp.
2937	J. B. Thompson, Jr.	Holland	"	Clay loam	Rus. Kl Wanz.
2938	"	"	"	"	Ger. "
3016	"	Toledo	"	Black loam	Vilmorin.
3017	"	"	"	"	Zehringen.
3070	G. W. Bamsey	Mitchaw	"	Mixed loam	Ger. Kl. Wanz.
3071	"	"	"	"	Rus. K "
	Average 11 samples.				

INVESTIGATIONS IN OHIO FOR 1900—Continued.

Date of planting.	Width between rows—inches.	Date of sampling	Date of analysis.	Average weight of beets—ozs.	Sucrose in beets—per cent.	Purity coefficient.	Laboratory. No.
May 1	24	Oct. 23	Oct. 23	13.5	7.5	75.2	2877
April 25	24	" 22	" 23	5.9	7.6	72.7	2878
				9.7	7.5	73.9	
June 15	24	Nov. 9	Nov. 10	10.6	8.5	74.4	3057
" 15	24	" 9	" 10	7.8	9.1	71.1	3058
				9.2	8.8	72.7	
April 25	30	Oct. 22	Oct. 26	29.6	10.4	73.1	2899
" 25	30	" 22	" 26	21.1	7.6	65.9	2900
" 25	30	" 22	" 26	26.1	7.8	62.5	2901
" 25	30	" 22	" 26	30.	11.	73.9	2902
May 16	30	Nov. 13	Nov. 17	28.2	12.7	84.7	3080
				27.0	9.9	72.0	
April 16	18	Nov. 2	Nov. 6	9.4	9.2	69.3	2992
April 25	24	Oct. 24	Oct. 29	29.1	10.9	78.1	2921
May 24	20	Oct. 20	Oct. 22	16.5	13.5	82.5	2863
" 26	20	" 20	" 22	16.7	12.7	84.7	2864
April 3	16	" 29	Nov. 3	14.2	13.2	85.3	2966
" 3	16	" 29	" 3	11.	12.8	85.4	2967
" 3	16	" 29	" 3	10.4	12.1	82.	2968
" 3	16	" 29	" 3	9.	13.	84.	2969
June 5	18	Nov. 3	" 6	6.4	13 8	81.9	2993
" 5	18	" 3	" 6	10.6	14.6	84.6	2994
" 5	18	" 3	" 6	7.7	13.2	79.9	2995
April 20		" 5	" 8	12.	13.3	85.4	3034
" 20	22	" 5	" 8	10.8	14.5	84.5	3035
May 4	18	" 7	" 8	12.7	11.	78.9	3043
" 20	24	" 8	" 13	13.2	13.3	77.8	3066
" 20	24	" 8	" 13	8.	15.3	83.8	3067
" 20	24	" 8	" 13	8.6	14.4	82.2	3068
" 20	24	" 8	" 13	8.1	11.9	76.1	3069
				11.2	13.3	82.4	
April 2	36	Oct. 19	Oct. 22	21.7	12.7	80.7	2859
" 2	36	" 19	" 22	19.4	13.1	81.8	2860
" 2	36	" 19	" 22	24.7	14.6	83.7	2861
" 2	36	" 20	" 22	17.	12.8	80.3	2862
				20.7	13.3	81.6	
			Nov. 3	11.4	14.2	83 2	2951
			" 3	11.6	14.9	85.3	2952
				11.4	14.5	84.2	
April 28	18	Nov. 9	Nov. 13	12.2	12.8	75.6	3061
" 28	18	" 9	" 13	7.1	13.3	78.2	3062
" 28	18	" 9	" 13	14.7	12.8	77.	3063
" 28	18	" 9	" 13	10.6	12.7	77.5	3064
				11.1	12.9	77.0	
May 15	18	Nov. 8	Nov. 10	20.6	8 6	64.5	3059
" 7	36	" 8	" 10	20.1	9.6	64.4	3060
" 7	36	" 8	" 13	26.9	9.1	67.	3072
				23.5	9.1	65.3	
May 2	19	Oct. 20	Oct. 23	19.4	9.9	74.3	2879
April 20	20	" 22	" 23	10.5	12.7	83.7	2882
" 20	36	" 22	" 23	10.5	13.3	88.1	2883
" 20	20	" 22	" 23	21.	12.2	79.5	2884
" 20	20	" 22	" 23	11.	14.	84.	2885
" 24	18	" 29	Nov. 3	6.2	11.	80.	2937
" 24	18	" 29	" 3	6.3	12.3	84.4	2938
May 3	18	Nov. 5	" 6	5.4	11.3	81.5	3016
" 3	18	" 5	" 6	16.6	9 5	80.	3017
April 20	24	" 10	" 13	18.5	13.	83.5	3070
" 20	24	" 5	" 13	13.5	11.6	81 9	3071
				12.6	11.9	81.9	

TABLE IV: DETAILED RESULTS OF SUGAR BEET

Laboratory No.	Name of grower.	Postoffice.	County.	Character of soil.	Variety.
2880	A. D. Hall	Litchfied	Medina	Blk. loam	Ger. Kl. Wanz.
2881	G. L. Damon	"	"	Sdy. bottom	"
2898	N. N. Reese	Chippewa Lake	"	" soil	
2909	S. A. Rhodes	Litchfield	"	Loam clay	Rus.Kl. Wanz
2939	Chauncy Hunt	Mallet Creek	"	Clay	"
2940	Chris. Kaiser	Erhart	"	"	"
2945	J. B. Good	Blake	"	Blk. loam	
2943	J. C. Fortney	Litchfield	"	Sandy	Kl. Wanz.
2947	Wm. Stroa·ker	Liverpool	"	Loam	"
2930	George Hard	"	"	"	
2961	W. Wiler	Whittlesey	"	Sd. loam	
2976	C. M. Metzger	Liverpool	"	Blk. clay	Kl. Wanz.
3018	Geo Rolling	"	"	"	"
3025	Ed Smith	Medina	"	Blk loam	"
3033	Andrew Metzger	Liverpool	"	Clay and sand	"
3035	Nelson Smith	Medina	"	Sand and clay	"
3039	Fred Kleinknecht	Liverpool	"	"	"
3044	Winthorp Hill	Windfall	"	Sdy. loam	"
3048	A. F. Rickert	"	"	"	"
3053	H. L. Walling	Medina	"	Sandy	
3055	F. W. Weidner	Liverpool	"	Blk. loam	Kl. Wanz.
3083	G. M. Brainerd	Windfall	"	" clay	"
	Average, 22 samples.				
2891	W. B. Doner	Wabash	Mercer	Lt. sand	Kl Wanz.
2892	"	"	"	"	Rus. Kl. Wanz.
3054	Moore McMillan	Macedon	"	Sandy	
	Average, 3 samples				
2836	Karl G. Korn	Dayton	Montgom'ry	Clay loam	Knauer.
2837	"	"	"	"	"
2838	"	"	"	"	"
2839	R. H. Dickey, Jr.	"	"	"	"
2840	"	"	"	"	"
	Average 5 samples.				
2903	L. P. & C. B. Roemer	Duncan Falls	Muskingum.	Sandy	Zehringen.
2904	"	"	"	"	Vilmorin.
	Average, 2 samples.				
2910	John C. Metzger	Oak Harbor	Ottawa		
2841	C. H. Allen.	Paulding	Paulding	Blk. loam	
3005	"	"	"	"	
3021	Elmer Jameson	Haviland	"	Blk. clay	
3022	"	"	"	"	White Imp.
3023	"	"	"	"	Kl. Wanz.
3024	"	"	"	"	Zehringen.
	Average, 6 samples.				
2984	J. C. Scott	Diamond	Portage	Clay loam	White Imp.
2985	"	"	"	"	Kl. Wanz.
2986	"	"	"	"	Zehringen
2987	"	"	"	"	Kl. Wanz.
	Average, 4 samples.				
2875	W. W. Dibble	Prentiss	Putnam	Loam	Kl. Wanz.
2876	"	"	"	"	Russian.
2911	Frank Koharst	Ft. Jennings	"	Blk. loam	French Yellow.
2933	John F. Clevenger	Kalida	"	"	Rus. Kl. Wanz.
2934	"	"	"	"	White Improved
2935	"	"	"	"	Zehringen.
2936	"	"	"	"	Ger. Kl Wanz.
2953	A. J. Troyer	Hector	"	Clay loam	Rus. Kl. Wanz.
2954	"	"	"	"	"
2955	"	"	"	"	White Improved.
2956	"	"	"	"	Zehringen.
3022	John A Alkire	Pandora	"	Blk. loam	White Vilmorin
	Average, 12 samples				

INVESTIGATIONS IN OHIO FOR 1900—Continued.

Date of Planting.	Width between rows—inches.	Date of sampling.	Date of analysis.	Average weight of beets—ozs.	Sucrose in beets—per cent.	Purity coefficient.	Laboratory number.
May 21	30	Oct. 22	Oct. 23	12.4	7.	57.8	2880
" 19	36	" 19	" 23	11.4	11.1	76.4	2881
" 15	....	" 24	" 25	12.5	13.5	82.1	2898
June 2	14	" 25	" 27	14.	13.3	84.3	2909
" 10	30	" 27	Nov. 3	9.3	12.9	82.4	2939
May 15	20	" 29	" 3	6.	9.	71.4	2940
" 20	20	" 27	" 3	19.4	13.7	81.8	2945
" 10	12	" 29	" 3	9.2	15.1	86.4	2946
April 28	18	" 28	" 3	14.2	12.3	80.2	2947
....	....	....	" 3	43.	9.5	69.	2950
May 15	30	Oct. 29	" 3	7.4	10.4	73.8	2961
" 10	....	Nov. 3	" 3	11.	11.4	82.2	2976
" 2	16	" 2	" 6	27.5	7.1	68.8	3018
" 10	30	" 5	" 6	11.2	12.8	83.8	3025
June 1	30	" 5	" 8	20.6	11.5	82.3	3033
April 30	20	" 5	" 8	5.3	13.2	82.7	3035
May 5	24	" 5	" 8	18.	13.4	83.4	3039
" 5	....	" 5	" 8	12.5	12.3	82.2	3044
" 14	30	" 6	" 9	8.1	14.9	85.3	3048
" 30	20	" 6	" 9	12.7	11.5	77.6	3053
April 25	36	" 9	" 10	38.4	9.9	70.3	3055
May 2	18	" 12	" 17	13.5	13.3	83.8	3083
				15.3	11.7	78.3	
April 27	24	Oct. 23	Oct. 24	21.6	8.1	70.2	2891
" 27	24	" 23	" 23	24.	7.3	66.3	2892
May 15	20	Nov. 7	Nov. 9	17.3	10.7	73.3	3054
				20.9	8.7	69.9	
June 28	16	Oct. 6	Oct. 15	30.5	9.1	68.6	2836
" 28	16	" 6	" 15	25.3	8.2	64.6	2837
" 28	16	" 6	" 15	17.5	10.5	71.6	2838
May 10	16	" 12	" 15	23.8	6.7	57.7	2839
" 10	16	" 10	" 15	20.2	10.	71.9	2840
				23.4	8.9	66.8	
May 18	26	ct. 25	Oct. 26	15.2	9.	67.3	2903
" 18	20	" 25	" 26	15.6	8.3	67.9	2904
				15.4	8.6	67.6	
....	....	....	Oct.	19.5	14.83	86.7	2910
May 10	30	Oct. 5	" 15	15.4	13.8	78.7	2841
June 8	42	Nov. 10	Nov. 13	16.5	12.7	77.5	3005
April 19	21	" 5	" 6	14.3	11.9	82.3	3021
" 19	21	" 5	" 6	8.2	13.2	87.4	3022
" 19	21	" 5	" 6	10.	13.2	84.2	3023
" 19	21	" 5	" 6	10.1	12.8	88.2	3024
				12.4	12.9	83.0	
April 16	20	Nov. 3	Nov. 6	13.	12.2	77.1	2984
" 16	20	" 3	" 6	17.	12.5	76.7	2985
" 16	20	" 3	" 6	18.1	13.8	80.1	2986
" 16	20	" 3	" 6	11.1	12.8	78.	2987
				14.8	12 8	77.9	
April 28	18	Oc . 22	Oct. 33	22.37	10.5	78.1	2875
" 30	18	" 22	" 23	8.39	12.3	80.7	2876
May 16	36	" 23	" 27	13	7.1	67.5	2911
" 23	18	" 27	Nov. 3	10.1	10.1	75.2	2933
" 23	18	" 27	" 3	17.7	10.5	76.	2934
" 23	18	" 27	" 3	19.4	8.5	70.9	2935
" 23	18	" 27	" 3	17.5	11.5	78.	2936
April 28	24	" 29	" 3	14.	11.2	77.1	2953
" 29	24	" 29	" 3	24.2	9.1	71.1	2954
" 39	24	" 29	" 3	20.7	10.4	81.5	2955
" 18	24	" 29	" 3	11.1	11.3	83.2	2956
May 17	16	Nov. 5	" 8	3.	10.4	75.7	3022
				15.12	10.2	76.2	

TABLE IV: DETAILED RESULTS OF SUGAR BEET

Laboratory No.	Name of grower.	Postoffice.	County.	Character of soil.	Variety.
2912	E. M. Ater	Clarksburg	Ross	Blk. muck	Rus. Kl. Wanz.
2913	"	"	"	Garden	White improved
2914	"	"	"	Blk. clay	Zehringen.
2915	"	"	"	"	Ger. Kl. Wanz.
	Average, 4 samples.				
2800	Theo. Rosenberger	Fremont	Sandusky		Rus. Kl. Wanz.
2801	"	"	"	Blk. loam	Ger. "
2843	C. H. Thomas	"	"		"
2920	Joseph H. Vine	Vickery	"	Clay	"
2926	I. W. Walton	Fremont	"	Blk loam	
2927	"	"	"	Clay loam	
2948	W. F. Conner	"	"	Blk. sand	Kl. Wanz.
2949	"	"	"	"	"
2957	G. W. Parker	Clyde	"	Red. sand	"
3037	T. F. Siegfried	Fremont	"	Blk sand	"
3038	"	"	"	"	"
3040	Theo. Rosenberger	"	"	Blk. loam	Rus. Kl. Wanz.
3041	"	"	"	"	Ger. Kl. Wanz.
3046	Henry Herman	Woodville	"	Dark loam	Vilmorin.
3047	Chas. Flicker	Gibsonburg	"		
3056	M. H. Crowell	Fremont	"	Blk. loam	Vilmorin.
3077	Michael Oberst	"	"	"	Orig. Kl. Wanz.
	Average, 17 samples.				
2905	Ernest R. Conklin	McCutchenvile	Seneca	Clay and sand.	Rus. Kl. Wanz.
2906	"	"	"	"	Zehringen.
2907	"	"	"	"	Imp. Vilmorin.
2908	"	"	"	"	Ger. Kl. Wanz.
	Average, 4 samples.				
2865	Barney Schmidt	Botkins	Shelby	Blk. sand	Ger. Kl. Wanz.
2866	"	"	"	"	"
	Average, 2 samples				
2962	F. M. Frederick	Wilmot	Stark	Clay	Rus. Kl. Wanz.
2963	"	"	"	"	"
2964	"	"	"	"	Vilmorin.
2965	"	"	"	"	Zehringen
	Average, 4 samples.				
2886	Bert M. Hart	West Richfield	Summit	Clay loam	Zehringen.
2887	"	"	"	"	White Vilmorin.
2888	"	"	"	"	Ger. Kl. Wanz.
2889	"	"	"	"	Rus. "
	Average, 4 samples.				
2960	C. H. Cook	Johnsonville	Trumbull	Clay loam	White Vilmorin.
2894	C. D. Wells	Van Wert	Van Wert	Sandy	Vilmorin.
2895	"	"	"	"	Zehringen.
2896	"	"	"	"	Kl. Wanz.
2897	"	"	"	"	Ger. "
2916	J. M. Geise	Delphos	"	Blk. sand	Rus. "
2917	"	"	"	"	Zehringen.
2918	"	"	"	"	Ger. Kl Wanz.
2919	"	"	"	"	Imp. Vilmorin.
2972	F. B. Collins	Van Wert	"	Sandy	Zehringen.
2973	"	"	"	"	"
2980	David Eichar	Willshire	"	"	"
2981	"	"	"	"	Ger. Imp. Vil.
2982	"	"	"	"	Rus. Kl. Wanz.
2983	"	"	"	"	"
	Average, 14 samples.				
2988	H. P. Paffenbarger	McArthur	Vinton	Sandy loam	Kl. Wanz.
2989	"	"	"	"	"
2990	"	"	"	"	Imp. Vilmorin.

INVESTIGATIONS IN OHIO FOR 1900.

Date of planting.	Width between rows—inches.	Date of sampling.	Date of analysis.	Average weight of beets—ozs.	Sucrose in beets—Per cent.	Purity coefficient.	Laboratory No.
April 12	24	Oct. 23	Oct. 27	6.5	7.7	72.3	2912
" 3	18	" 25	" 27	8.1	7.2	70.	2913
" 14	24	" 23	" 27	7.1	10.6	81.8	2914
" 12	24	" 25	" 27	6.4	10.	76.6	2915
				7.0	8.9	75.2	
....	18	....	....	52.	10.9	77.1	2800
....	18	....	....	36.5	12.9	79.3	2801
....	....	....	Oct. 18	44.	11.1	78.	2848
May 10	20	Oct. 28	" 27	21.88	11.6	79.5	2920
April 28	20	" 28	" 29	14.2	13.1	82.1	2926
" 28	20	" 27	" 29	11.6	12.8	81.8	2927
May 23	30	" 15	Nov. 3	21.	12.8	80.8	2948
" 23	20	" 30	" 3	21.4	14.3	81.2	2949
April 9	36	" 29	" 3	13.	9.2	73.9	2957
May 7 and 24	....	" 30	" 8	11.3	15.3	84.7	3037
" 7 and 24	20	" 30	" 8	11.	16.5	87.4	3038
April 19	16	" 17	" 8	18.8	13.	85.1	3040
" 19	16	" 17	" 8	19.	12.3	84.	3041
May 12	20	Nov. 6	" 8	22.	14.2	81.4	3046
....	....	....	" 9	29.6	12.3	77.8	3047
April 30	20	Nov. 8	" 10	16 3	13.4	84.9	3056
May 2	20	" 12	" 13	21.	13.8	79.1	3077
				22.6	12.9	81.2	
June 1	18	Oct. 25	Oct. 27	9.2	10.3	74.5	2905
" 1	18	" 25	" 27	12.8	10.5	76.	2906
" 1	18	" 26	" 27	15.	10.6	73.2	2907
" 1	18	" 25	" 27	12.8	11.1	75.4	2908
				12.4	10.6	74.7	
May 1	42	Oct. 18	Oct. 22	8.9	12.3	77.8	2865
" 1	42	" 18	" 22	9.9	13.2	83.2	2866
				9 2	12.7	80.5	
April 21	30	Oct. 29	Nov. 3	9.3	10.5	81.6	2962
" 21	30	" 29	" 3	8.3	12.3	78.3	2963
" 21	30	" 29	" 3	7.8	10.4	81.5	2964
" 21	30	" 29	" 3	14.2	9.2	78.	2965
				9.9	10.6	79.8	
April 16	30	Oct. 22	Oct. 23	11.	10.	75.6	2886
" 16	30	" 22	" 23	17.	9.3	71	2887
" 16	30	" 22	" 23	11.8	10.2	75.3	2888
" 16	30	" 22	" 23	19.	9.4	75.4	2889
				14.7	9.7	74.3	
June 9	18	Oct. 29	Nov. 3	7.8	13.4	82.4	2960
April 26	24	" 24	Oct. 25	8.7	8.1	70.2	2894
" 26	24	" 24	" 25	8.	9.9	70.3	2895
" 26	24	" 24	" 25	9.4	9.9	71.2	2896
" 26	24	" 24	" 24	10.6	10.6	74.2	2897
March 22	24	" 24	" 27	19.5	9.1	74.4	2916
" 22	24	" 24	" 27	19.2	9.5	71.9	2917
" 22	24	" 24	" 27	17.1	10.6	76.7	2918
" 22	24	" 24	" 27	22.4	9.6	71.6	2919
April 5	36	Nov. 1	Nov. 3	27.8	9.	70.7	2972
" 5	36	" 1	" 3	26.8	5.1	60.	2973
May 10	24	" 1	" 6	14.	9.7	69.9	2980
" 10	24	" 1	" 6	13.5	7.5	67.5	2981
" 10	24	" 1	" 6	10.1	11.4	78.4	2982
" 10	24	" 1	" 6	10.7	10.5	75.5	2983
				14.9	9.3	71.6	
April 3	20	Oct. 30	Nov. 6	6.8	11.2	71.8	2988
" 3	20	" 30	" 6	19.8	6.6	54.5	2989
" 3	20	" 29	" 6	6.	9.7	70.8	2990

TABLE IV: DETAILED RESULTS OF SUGAR BEET

Laboratory No.	Name of grower.	Postoffice.	County.	Character of soil.	Variety.
2991	H. P. Peffenberger	McArthur	Vinton	Sandy loam	Zehringen.
	Average, 4 samples.				
2922	Mrs. Shumaker	Lebanon	Warren	Clay loam	Imp. Vilmorin.
2923	"	"	"	"	Zehringen.
2924	"	"	"	"	Kl. Wanz.
2925	"	"	"	"	"
	Average, 4 samples.				
2802	Ohio Agr. Exp. Station	Wooster	Wayne	Silt loam	Kl. Wanz.
2803	" "	"	"	"	White Improved.
2804	" "	"	"	"	Zehringen.
2805	" "	"	"	"	Rus. Kl. Wanz.
2806	" "	"	"	"	"
2807	" "	"	"	"	"
2808	" "	"	"	"	Imp. White.
2809	" "	"	"	"	Zehringen.
2810	" "	"	"	"	Rus. Kl. Wanz.
2811	" "	"	"	"	"
2812	" "	"	"	"	"
2813	" "	"	"	"	Licht.
2814	" "	"	"	"	Vilmorin.
2815	" "	"	"	"	Zehringen.
2816	" "	"	"	"	Rus. Kl. Wanz.
2817	" "	"	"	"	"
2818	" "	"	"	"	"
2819	" "	"	"	"	"
2820	" "	"	"	"	White Improved.
2821	" "	"	"	"	Zehringen.
2822	" "	"	"	"	Kl. Wanz.
2823	" "	"	"	"	Rus. Kl. Wanz.
2824	" "	"	"	"	Kl. Wanz.
2825	" "	"	"	"	Vilmorin
2826	" "	"	"	"	Zehringen.
2827	" "	"	"	"	Rus. Kl. Wanz.
2828	" "	"	"	"	"
2829	" "	"	"	"	"
2830	" "	"	"	"	Licht.
2831	" "	"	"	"	Vilmorin.
2832	" "	"	"	"	Zehringen.
2833	" "	"	"	"	Rus. Kl. Wanz.
2834	" "	"	"	"	"
2835	" "	"	"	"	"
2842	I. W. Knestrick	Creston	"		
2844	H. B. Heckman	Funk	"		Zehringen.
2845	"	"	"		Rus. Kl. Wanz.
2846	"	"	"		Vilmorin.
2847	"	"	"		Kl. Wanz.
2867	Joseph Gault	Wooster	"	Rich bottom	Russian.
2868	"	"	"	"	German.
2869	"	"	"	Muck	Russian.
2870	"	"	"	"	German.
2932	Edward Amict.	Koch	"	Sandy loam	Zehringen.
2999	Ohio Agr. Exp. Station	Wooster	"	Silt loam	Kl. Wanz.
3000	" "	"	"	"	Vilmorin.
3001	" "	"	"	"	Zehringen.
3002	" "	"	"	"	4416
3003	" "	"	"	"	3943
3004	" "	"	"	"	3944
3005	" "	"	"	"	3941
3006	" "	"	"	"	3942
3007	" "	"	"	"	3943
3008	" "	"	"	"	4416
3009	" "	"	"	"	3944
3010	" "	"	"	"	1900
3011	" "	"	"	"	3941
3012	" "	"	"	"	3942
3013	" "	"	"	"	3943
3014	" "	"	"	"	4416
3015	" "	"	"	"	3944
3030	Timothy Buckley	"	"	Muck	French.
3031	"	"	"	"	German.
3078	John Begert	"	"	Gravel loam	Imp. Vilmorin.
3079	"	"	"	"	Rus. Kl. Wanz.
3081	"	"	"	"	"

INVESTIGATIONS IN OHIO FOR 1900.

Date of planting.	Width between rows—inches.	Date of sampling.	Date of analysis.	Average weight of beets—ozs.	Sucrose in beets—per cent.	Purity co efficient.	Laboratory No.
April 3	20	Oct. 29	Nov. 6	16.8	9.8	72.	2991
				12.3	9.3	67.3	
April 15	18	Oct. 27	Oct. 29	5.4	5.4	55.3	2922
" 15	18	" 27	" 29	7.	5.5	57.4	2923
" 15	18	" 27	" 29	8.	3.8	50.6	2924
" 15	18	" 27	" 29	7.5	5.9	66.	2925
				6.9	5.2	57.3	
April 14	....	Oct. 1	Oct. 2	3.4	9.	72.5	2802
" 14	....	" 1	" 2	3.7	9.1	76.2	2803
" 14	....	" 1	" 2	2.6	9.6	76.5	2804
" 14	....	" 1	" 2	3.6	8.5	70.3	2805
" 14	....	" 1	" 2	4.5	10.4	74.3	2806
" 14	....	" 1	" 2	7.4	9.2	72.9	2807
" 27	....	" 1	" 2	5.	9.7	73.9	2808
" 27	....	" 1	" 2	4.6	10.2	76.9	2809
" 27	....	" 1	" 2	3.1	10.2	73.3	2810
" 27	....	" 1	" 2	4.9	10.7	77.4	2811
" 27	....	" 1	" 2	3.5	11.4	80.5	2812
May 16	....	" 1	" 2	2.8	10.4	76.4	2813
" 16	....	" 1	" 2	3.	10 4	76.7	2814
" 16	....	" 1	" 2	4.6	9.5	73.	2815
" 16	....	" 1	" 2	5.	10.4	76.7	2816
" 16	....	" 1	" 2	4.6	9.5	71.1	2817
" 16	....	" 1	" 2	6.	9.4	75.	2818
April 14	....	" 15	" 15	2.8	10.4	74.8	2819
" 14	....	" 15	" 15	3.	10.4	73.8	2820
" 14	....	" 15	" 15	3.4	10.	78.3	2821
" 14	....	" 15	" 15	2.5	10.2	76.9	2822
" 14	....	" 15	" 15	3.6	10.9	78.7	2823
" 14	....	" 15	" 15	3.6	11.6	83.6	2824
" 27	....	" 15	" 16	5.4	10.6	77.2	2825
" 27	....	" 15	" 16	4.	11.	79.4	2826
" 27	....	" 15	" 16	5.	10.5	77.6	2827
" 27	....	" 15	" 16	3.6	11.	78.9	2828
" 27	....	" 15	" 16	5.9	10.5	80.4	2829
May 16	....	" 15	" 16	5.6	10.5	77.6	2830
" 16	....	" 15	" 16	5.3	10.2	78.1	2831
" 16	....	" 15	" 16	5.4	10.	76.1	2832
" 16	....	" 15	" 16	4.7	9.7	76.1	2833
" 16	....	" 15	" 16	4.	9.5	79.4	2834
" 16	....	" 15	" 16	6.3	10.9	79.8	2835
....	....	....	" 18	3.2	10.4	87.3	2842
....	....	Oct. 19	" 20	27.2	9.	76.6	2844
....	....	" 19	" 20	28.	6.1	68.4	2845
....	....	" 19	" 20	33.7	9.2	76.4	2846
....	....	" 19	" 20	25.5	9.	73.1	2847
May 25	....	" 22	" 22	50.4	8.1	70.8	2867
" 25	....	" 22	" 22	51.	8.8	75.	2868
" 25	....	" 22	" 22	26.3	9.	73.6	2869
" 25	....	" 22	" 22	28.	9.2	76.4	2870
" 20	....	" 26	" 29	19.	11.5	77.5	2932
April 14	....	Nov. 5	Nov. 6	51.	11.8	77.	2999
" 14	....	" 5	" 6	4.4	12.8	79.4	3000
" 14	....	" 5	" 6	5.4	11.9	76.3	3001
" 14	....	" 5	" 6	11.5	10.5	76.	3002
" 14	....	" 5	" 6	4.	12.7	84.3	3003
" 14	....	" 5	" 6	5.1	12.9	79.1	3004
" 27	....	" 5	" 6	....	11.9	78.1	3005
" 27	....	" 5	" 6	5.1	11.5	79.	3006
" 27	....	" 5	" 6	4.6	12.3	80.	3007
" 27	....	" 5	" 6	4.7	11.9	80.6	3008
" 27	....	" 5	" 6	4.	12.8	80.3	3009
May 16	....	" 5	" 6	4.3	13.	79.6	3010
" 16	....	" 5	" 6	5.3	12.8	81.8	3011
" 16	....	" 5	" 6	6.4	13.9	81.6	3012
" 16	....	" 5	" 6	5.1	13.7	80.9	3013
" 16	....	" 5	" 6	3.3	12.6	79.9	3014
" 16	....	" 5	" 6	3.5	13.8	80.1	3015
" 3	24	" 5	" 7	12.	6.7	67.	3030
" 3	24	" 5	" 7	16.4	6.6	64.8	3031
April 16	24	" 13	" 17	15.	12.9	78.6	3078
" 16	24	" 13	" 17	19.	8.2	69.3	3079
" 16	24	" 13	" 17	22.2	12.2	81.5	3081

TABLE IV: DETAILED RESULTS OF SUGAR BEET

Laboratory No.	Name of grower.	Postoffice.	County.	Character of soil.	Variety
3082	John Begert	Wooster	Wayne	Gravel loam	Zehringen.
3098	Ohio Agr. Exp. station	"	"	Silt loam	Ger. Kl Wanz.
3099	" "	"	"	"	White Improved
3100	" "	"	"	"	Zehringen.
3101	" "	"	"	"	Rus. Kl. Wanz.
3102	" "	"	"	"	" "
3103	" "	"	"	"	Ger. "
3104	" "	"	"	"	White Improved.
3105	" "	"	"	"	Zehringen.
3106	" "	"	"	"	Rus. Kl. Wanz
3107	" "	"	"	"	" "
3108	" "	"	"	"	Ger. "
3109	" "	"	"	"	Kl. Wanz Lich.
3110	" "	"	"	"	White Improved
3111	" "	"	"	"	Zehringen.
3112	" "	"	"	"	Rus. Kl. Wanz
3113	" "	"	"	"	" "
3114	" "	"	"	"	Ger "
	Average, 84 samples				
2890	E. P. Swander	Weston	Wood	Sandy loam	Rus. Kl. Wanz.

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INVESTIGATIONS IN OHIO FOR 1900—Concluded.

Date of planting.		Width between rows—inches.	Date of sampling.		Date of analysis.		Average weight of beets—ozs.	Sucrose in beets—per cent.	Purity co-efficient.	Laboratory No.
April	16	24	Nov.	13	Nov.	17	15.5	12.	80.8	3082
"	14	....	"	19	"	20	4.8	12.3	76.6	3098
"	14	....	"	19	"	20	3.1	12.3	78.3	3099
"	14	....	"	19	"	20	4.6	11.5	76.7	3100
"	14	....	"	19	"	20	4.5	10.2	72.8	3101
"	14	....	"	19	"	20	5.8	10.4	76.9	3102
"	14	....	"	19	"	20	5.	10.5	74.5	3103
"	27	....	"	19	"	20	4.	12.3	78.1	3104
"	27	....	"	19	"	20	4.7	11.7	78.9	3105
"	27	....	"	19	"	20	4.	11.6	77.2	3106
"	27	....	"	19	"	20	3.1	11.6	78.2	3107
"	27	....	"	19	"	20	4.4	12.3	80.2	3108
May	16	....	"	19	"	20	4.7	12.7	82.7	3109
"	16	....	"	19	"	20	4.1	11.9	79.3	3110
"	16	....	"	19	"	20	4.5	10.4	76.4	3111
"	16	....	"	19	"	20	2.6	11.	77.3	3112
"	16	....	"	19	"	20	1.4	11.7	77.3	3113
"	16	....	"	19	"	20	1.6	11.4	78.4	3114
							8.7	10.7	77.0	
March	20	18	Oct.	22	Oct.	23	9.8	12.1	82.5	2890

TABLE V: SUMMARY OF TABLE IV, 1900.

County.	No. of samples.	Average weight of beets, ozs.	Sugar in beets, per cent.	Purity coefficient.
NORTHERN SECTION.				
Ashland	4	10.3	10.7	78.5
Cuyahoga	6	7.8	12.4	79 6
Defiance	2	5.4	13.9	83 9
Fulton	5	27.0	9.9	72.0
Hancock	1	29.1	10.9	78 1
Henry	16	11.2	13.3	82.4
Lake	4	11.1	12 9	77.0
Lorain	3	23.5	9.1	65.3
Lucas	11	12.6	11.9	81.9
Medina	22	15.3	11.7	78.5
Ottawa	1	19.5	14 8	86 7
Paulding	6	12 4	12 9	83 0
Portage	4	14.8	12.8	77.9
Putnam	12	15.1	10.2	76.2
Sandusky	17	22.6	12.9	81.6
Seneca	4	12.4	10.6	74.7
Stark	4	9.9	10.6	79.8
Summit	4	14.7	9.7	74.3
Trumbull	1	7.8	13.4	82.4
Van Wert	14	14.8	9.3	71.6
Wayne	84	8.7	10.7	77.0
Wood	1	9.8	12.1	82 5
MIDDLE SECTION.				
Belmont	1	6.2	14.3	83.0
Champaign	14	16.2	11.5	79.5
Clark	9	13.4	9 4	76.9
Coshocton	8	20.9	10.0	73.8
Darke	6	8.4	10 2	78.8
Delaware	4	25.0	10.0	78.0
Franklin	2	9.2	8.8	72.7
Holmes	4	20.7	13 3	81.6
Knox	2	11.4	14 5	84.2
Mercer	3	20.9	8.7	69 9
Muskingum	2	15.4	8 6	67.6
Shelby	2	9.4	12.7	80.5
SOUTHERN SECTION.				
Fayette	2	9.7	7.5	73.9
Greene	1	9.4	9.2	69.3
Montgomery	5	23.4	8.9	66 8
Ross	4	7.0	8 9	75 2
Vinton	4	12.3	9.3	67.3
Warren	4	6.9	5.1	57 3
SUMMARY.				
Northern Section	226	12.6	11.3	77.8
Middle Section	57	15.9	10.7	77.4
Southern Section	20	12.5	8.1	67 5
Entire State	303	13.2	10.9	77.1

The results are, as a whole, disappointing to those who looked upon the past season as favorable to sugar beets; the fact is that the season was a favorable one for a stand of beets and possibly also for the tonnage secured, while the most unfavorable for sugar content and purity coefficient in the beets since the present sugar beet experiments were inaugurated, in 1897. The average of the analyses for the northern section is 11.3 per cent. sugar in beets and 77.8 purity coefficient; for the middle section 10.7 per cent. sugar in beets and 77.4 purity; for the southern section 8.1 per cent. sugar and 67.5 purity; while for the whole state the results give an average of 10.9 per cent. sugar in beets and a purity of 77.1. The counties of the northern section appear to be even more decidedly in the lead with respect to quality of beets analyzed, than in other seasons. Sandusky and Henry counties, in which beets were largely grown for the factory at Fremont, indicate the beneficial effects of supervision and better care in growing sugar beets.

Table VI gives a comparison of the general results of the sugar beet analyses by sections and for the entire state during 1897, 1898, 1899 and 1900, and certainly exhibits decided fluctuations; in short the results for 1900 are the most unsatisfactory of all the years covered. It will not be easy to offer a single really adequate explanation of the decided differences in the averages for the years 1897 and 1898 on the one hand, and those of 1899 and 1900 on the other. From fairly satisfactory results in 1897 and 1899 there is much deviation in 1898 and 1900. If we are to seek an explanation we are rather more likely to find one in the conditions which favor or retard the maturity of the beets and their elaboration of sugar; it would seem that these are synchronous.

TABLE VI: COMPARISON OF GENERAL RESULTS FOR 1897, 1898, 1899 AND 1900.

Section.	Number of samples.				Average weight of beets—ounces.				Sugar in beets—per cent.				Purity coefficient.			
	1897.	1898.	1899.	1900.	1897.	1898.	1899.	1900.	1897.	1898.	1899.	1900.	1897.	1898.	1899.	1900.
Southern section	67	51	20	20	31.4	18.4	21.6	12.5	12.2	10.9	12.1	8.1	75.3	76.9	77.5	67.5
Middle section	132	153	18	57	32.6	19.6	23.5	15.9	13.2	11.1	12.0	10.7	78.0	76.9	77.8	77.4
Northern section	355	294	93	226	29.2	25.0	20.5	12.6	13.6	11.6	13.0	11.3	78.4	78.7	81.5	77.8
Entire state	554	498	131	303	30.6	22.7	21.1	13.2	13.3	11.4	12.7	10.9	78.7	77.9	80.2	77.1

TABLE VII: VARIETIES PLANTED MAY 16, 1900

Date of analysis.	Improved Kleinwanzlebener (Licht) 1900.			White Improved (Vilmorin) 3941.			Zehringen (Strandes) 3942.			Russian Kleinwanzlebener (Mrozinski) 3943 and 4416			Ger. Kl. Wanzlebener (Dippé) 3944.		
	Average wt. of beets—grammes	Sugar in beets—per cent.	Purity.	Average wt. of beets—grammes	Sugar in beets—per cent.	Purity.	Average wt. of beets—grammes	Sugar in beets—grammes	Purity.	Average wt. of beets—grammes	Sugar in beets—grammes	Purity.	Average wt. of beets—grammes	Sugar in beets—per cent.	Purity.
October 2, 1900	80	10.4	76.4	86	10.4	76.7	136	9.5	73.	143 181	10.4 9.5	76.7 74.1	171	9.4	75
" 15, 1900	159	10.5	77.6	150	10.2	78.1	154	10.	76.1	141 111	9.7 9.5	76.1 79.4	177	10.9	79.8
November 6, 1900	123	13.	79.6	151	12.8	81.8	179	13.9	81.6	145 94	13 7 12.6	80.9 79.9	98	13.8	80.1
" 20, 1900	132	12.7	82.7	116	11.9	79.3	128	10.4	76.4	75.3 40.6	11. 11.7	77.3 77.3	46.6	11.4	78.4

VARIETY TESTS.

Five varieties of sugar beet seed, from as many European seed growers, were tested on some rather thin land at the Station, under the direction of the Chemist. A good stand of beets was secured at each planting, April 14, April 27 and May 16 respectively. Samples were taken at different dates and the results are exhibited in Table VII.

The maximum of quality in these beets, which were quite small, was obtained for the most part in those sampled November 6th. The details as to varietal differences are fully tabulated. There was a decidedly better stand in the field before thinning from numbers 3942, 3943 and 4416.

The original Kleinwanzlebener is reported to have given the best results in the beet sugar work at the Fremont factory. Six varieties are to be included in the co-operative tests, offered by this Station for 1901

THE BEET SUGAR INDUSTRY IN OHIO.

With the season of 1900, Ohio was enrolled among the states possessing a beet sugar factory; the Fremont works of the Continental Sugar Company, nominally a 350 ton plant, averaging 356 tons per day of 24 hours during the entire run, and slicing as high as 436 tons of beets per day, began running October 25, 1900, and closed December 26, 1900. This factory received 21,500 tons of beets, obtained from about 2,200 acres; by these figures a tonnage showing of about 9.8 tons per acre is the first year's results in this line. While from the sugar making side of the industry the low sugar content and purity of the beets have given, of necessity, less satisfactory results than should occur at another time, the yields of beets have been decidedly promising to the growers. Some failures and some highly profitable crops intersperse, as was to be expected, the general record for the year. Sugar beet growing is new to most of our farmers, and it is not expected that a single season will disclose all the knowledge of beet growing that it is possible for them to acquire. It is, however, from the general outlook, fairly reasonable to predict that this new industry will now claim an increasing amount of attention within our borders. A large modern plant has been constructed, has successfully handled the beets grown for it, and is again before the farming public of its vicinity for agreements as to next year's beet supply. Having started upon acreage contracted for but a single season, possible elements of discord are thereby greatly reduced, if not altogether avoided. After a season, the poorest for the period covered by our Station's sugar beet investigations, and one in which the beet yields have been above, rather than below, well grounded anticipations, Ohio growers are offered a liberal beet agreement for the year of 1901. It would appear to an outside observer that these conditions afford a

good opportunity to test fairly the future of the Ohio beet sugar industry for the region in which the factory is located.

If, as many believe, northern Ohio will be found adapted to the profitable growing of beets and the successful conduct of a beet sugar factory in working those beets, what is soon to be determined will have a marked effect upon the future agricultural practice in the regions concerned. It would seem opportune, therefore, to give some space to the discussion of certain phases of the new sugar industry.

THE BEET SUGAR FACTORY.

A modern beet sugar factory exhibits in the general construction the triumphs of mechanical skill and ingenuity, at the same time that its methods of actual sugar making are the result of careful chemical investigation and are controlled at almost every stage by chemical analysis. Herein we may find much to interest us; every detail of construction and arrangement is planned to serve its particular end.

The accompanying illustration (Figure 2) will convey an idea of the Fremont factory, and comparatively speaking, of other beet sugar factories employing the same processes. The beet storage is provided in sheds, into which the beets are discharged from wagons or unloaded from the cars. Each of these sheds has the bottom sloping to the middle, beneath which is the flume; in it the beets are carried by flowing water to the factory proper, and out of it they are lifted by a wheel and delivered to the washer. After washing, the beets are automatically thrown within reach of the carrier, by means of which they are taken to the top of the building and delivered to the weighing machine; this machine discharges at a definite weight, about 600 pounds, meanwhile recording the number of loads, and the beets drop into the hopper of the slicing machine. The curved knives of the slicer cut the beets into pencil-like strips, or *cossettes*, as they are called, which are in turn delivered to the open diffusion cell or chamber of the diffusion battery below, through the long, sloping spout. About two and one-half tons of *cossettes* are required to each cell of the diffusion battery; after filling, the newly filled chamber is placed last in the line of flow of the hot water passing through these chambers to extract the sugar, or other substances dissolved in the beet juices. Herein is the essential difference between diffusion and direct extraction of saccharine matter by grinding or crushing and subsequent pressure. The slicing into *cossettes* is the preparation of the beet for extraction of its juices by the diffusion process. All are more or less familiar with the primitive crushing and juice extraction practiced with sorghum, with apples and with other fruits as exemplifying the old process of juice extraction. (Figure 3)

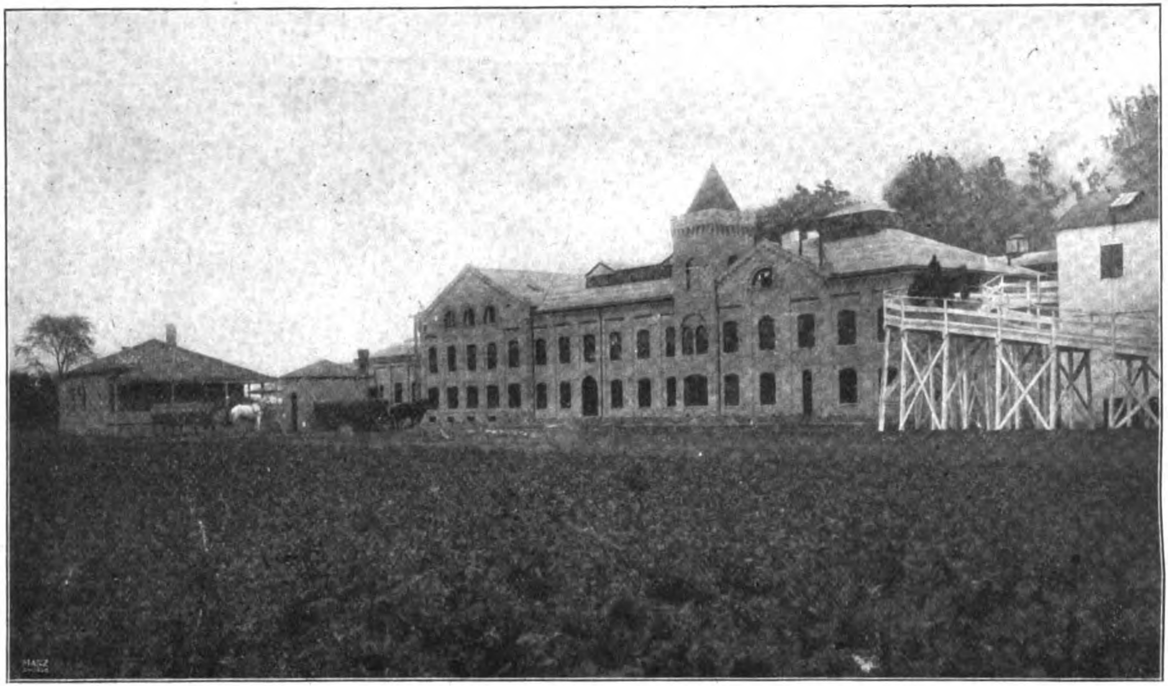

FIGURE 2.—A MODERN SUGAR BEET FACTORY.

The Fremont works of the Continental Sugar Company, Fremont. On the right is shown the end of the beet sheds nearest the factory, with empty wagon descending the incline; a similar incline at the farther end is for the ascent of the loaded wagons. In the center of the factory building, beneath the roof projection at the right hand of the tower, is situated the automatic weighing machine, slicer, and diffusion batteries. It is at this end of the factory that beets are taken in. The white sugar is discharged at the further end. The chemical laboratory is on the first floor, at the extreme left of the main building. The seed house is seen in the background at the left, and in the foreground the offices and scales. A beet field is in front of the factory.

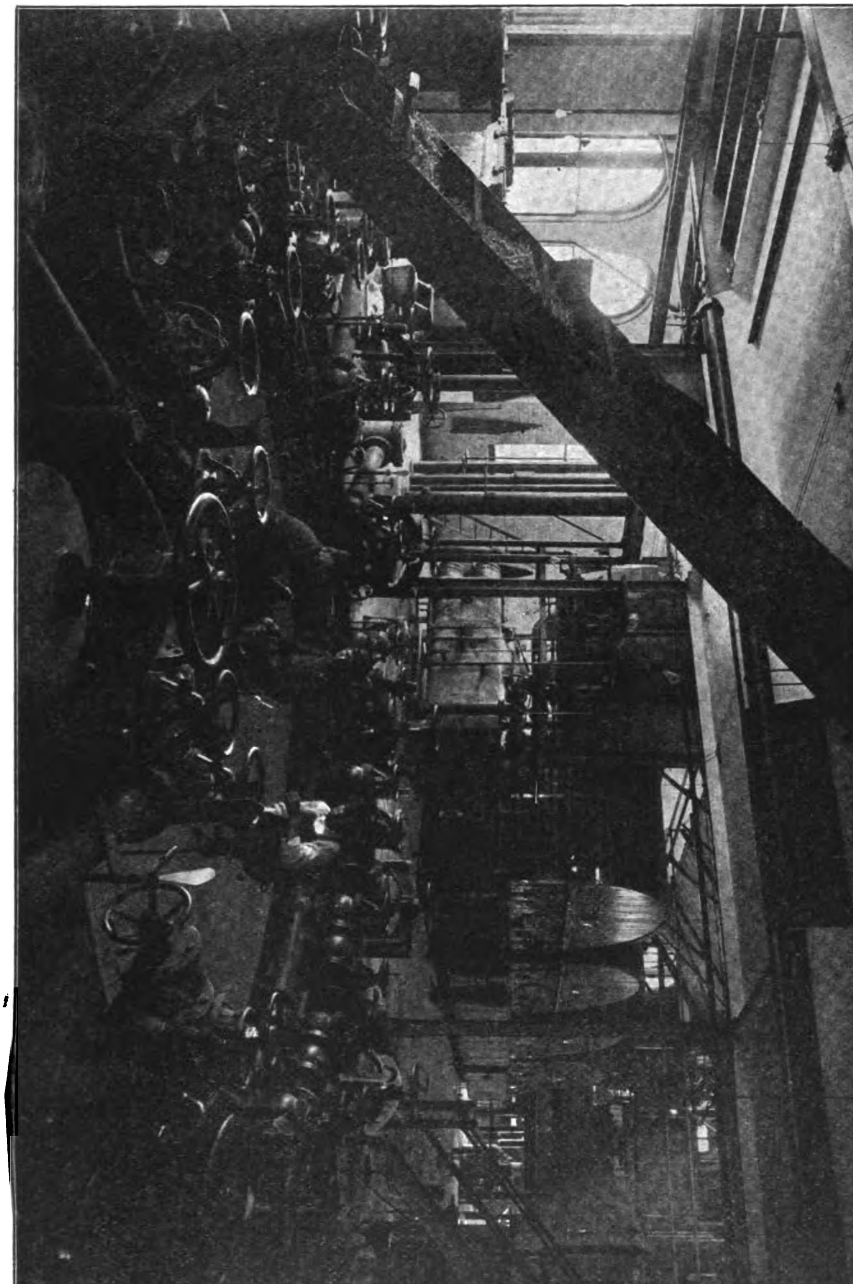

FIGURE 8.—Interior of the same factory, looking from the end toward the beet sheds, and showing in the foreground the diffusion battery, consisting of many large cells, with sliced beets discharging into one of them. In the background are visible the vacuum tanks, and in the extreme background, to the right, is shown that part of the factory in which the sugar is put into the barrels. (From photograph of Continental Sugar Co.)

The sugar juices from the diffusion cells will be diluted more or less, according to the volume of water used in their extraction; manifestly there is a limit in the extraction of the sugar from the *cosettes*, now become the *pulp*, beyond which profitable extraction cannot be secured because of the dilution of the diffusion juice.

Broadly speaking, about one-half of one per cent. of sugar remains in the pulp for the reasons stated; a more complete extraction would involve greater dilution and mean more water to evaporate in the process of sugar separation. The technical control of such processes involves many factors that will scarcely occur to the non-technical reader, or visitor at a beet-sugar factory.

The juice, or liquor from the diffusion battery, is passed through the sulfuring tanks where bleaching is to be secured by the fumes of burning sulfur; then the same liquor is passed to a tank for first carbonation. This process consists in the addition of lime in excess to precipitate especially the albuminoid substances in the juice and subsequently in passing gaseous carbon dioxid (saved in the process of burning the lime required) through this limed juice to precipitate any excess of lime and reduce, or neutralize the alkaline reaction. From the first carbonation the liquor is passed through the filter presses to remove all precipitated material, such as lime, albuminoid substances, and the like. From the filter presses come the lime cake of the factory. From the first set of filter presses the liquor passes through a second course of liming and carbonation, the "second carbonation" and again through a succeeding set of filter presses.

After the second carbonation, the somewhat changed juice or liquor is ready for the evaporating tanks, or vacuum tanks as they are usually called, where in a series of four tanks the liquor is evaporated, under reduced air pressure, to a "thick liquor" containing about fifty per cent. sugar. The vacuum tanks are interesting as illustrating the effect of the atmospheric pressure upon the boiling point of a liquid. These tanks are closed chambers, connected with each other and capable of containing a large volume of liquor. Through the tanks and liquor are a series of copper pipes. Through pipes of the first tank live steam is passed while the vapor from the evaporation going on in the first tank passes through the copper pipes of the second, and so for each one successively. The air is exhausted from the upper space of each chamber by trickling water and pump, so that a nearly uniform pressure is maintained for each, though different for the several tanks. This means about as follows:

For first vacuum tank normal pressure, boiling at 100 degrees C. (212 F.)

For second, a low vacuum, or a reduction of 2½ to 5 lbs. in the pressure, boiling at about 85 degrees C. (185 degrees F.)

For third, less pressure, about half of normal, boiling at about 65 degrees C. (149 degrees F.)

For fourth, an exhaustion of about 12 pounds, or a pressure of about 3 lbs., boiling at about 53 degrees C. (127.4 degrees F.)

The "thick liquor" from the vacuum tanks, containing, as is stated above, about 50 per cent. of sugar, is drawn off from the fourth tank, filtered through bag filters, sulfured again and then passed into "the vacuum strike pan" on the next level above. In this, evaporation proceeds under even better vacuum, until the desired consistency is reached for subsequent crystallization of the sugar. From the strike pan the thick, pasty mass is discharged into the graining pan, where it is continually stirred to induce proper crystallization; thence it is drawn to the centrifugals, which are chambers, or hollow cylindrical bodies with the outer margin of the hopper of perforated brass, revolving at a very high speed and surrounded by a fixed external jacket. The molasses is thus thrown out of the mass and caught by the external jacket; the crystallized sugar remains behind, is washed to free from adhering molasses and is then ready for drying in a heated dryer, and subsequent pulverizing of any lumps. As the finished sugar drops into the barrels, it is yet warm and almost entirely free from moisture, polarizing between 99.5 and 100 per cent. of sugar; in fact any slight deviation from 100 per cent. in polarization is usually to be attributed to imperfections in drying or to subsequent slight absorption of moisture.

There are further vacuum pans found here for the handling of molasses; and there are special processes, such as Steffen's, Osmose and some others, that have not been introduced into the Fremont works. The largest loss in beet sugar manufacture is undoubtedly in the final molasses, which in our country is not utilized, and is in fact, difficult to utilize even with pulp for stock feeding, as is reported to be the practice in Germany. The beet pulp too is not as yet utilized, though promising to be valuable in cattle feeding; it is dropped into a large silo outside the factory.

So much by way of explanation of the factory processes. Lime kilns, seed houses, cooper shops, boiler sheds and other features of a sugar factory do not differ essentially from similar features of any other industrial enterprise.

THE FARMERS' SIDE OF THE BEET SUGAR INDUSTRY.

It has been well said that the mechanics of the beet sugar industry has been brought to a high state of perfection in America, but that the agriculture of beet growing in our country has not advanced in proportion. If this be true even of states where the industry has been established longer than in Ohio, it is all the more certainly true with our people who have just begun. The point here worth making is that a considerable period of experience must be anticipated before great advances may be realized. If we but consider how much of experience is behind our usual growing of wheat, potatoes and corn, and further how much seems to be unsettled and yet to be acquired, we may appreciate the need for greater knowledge in the handling of a new crop of the

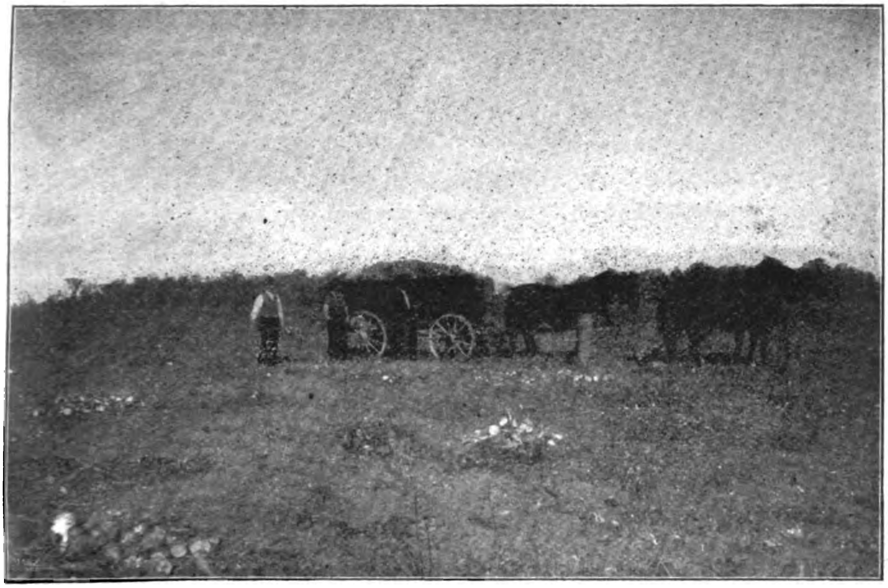

FIGURE 4.—Field operations in sugar beet growing: doubling up teams to haul wagons out of the beet fields. The wagons of this style carry 3 tons of beets.

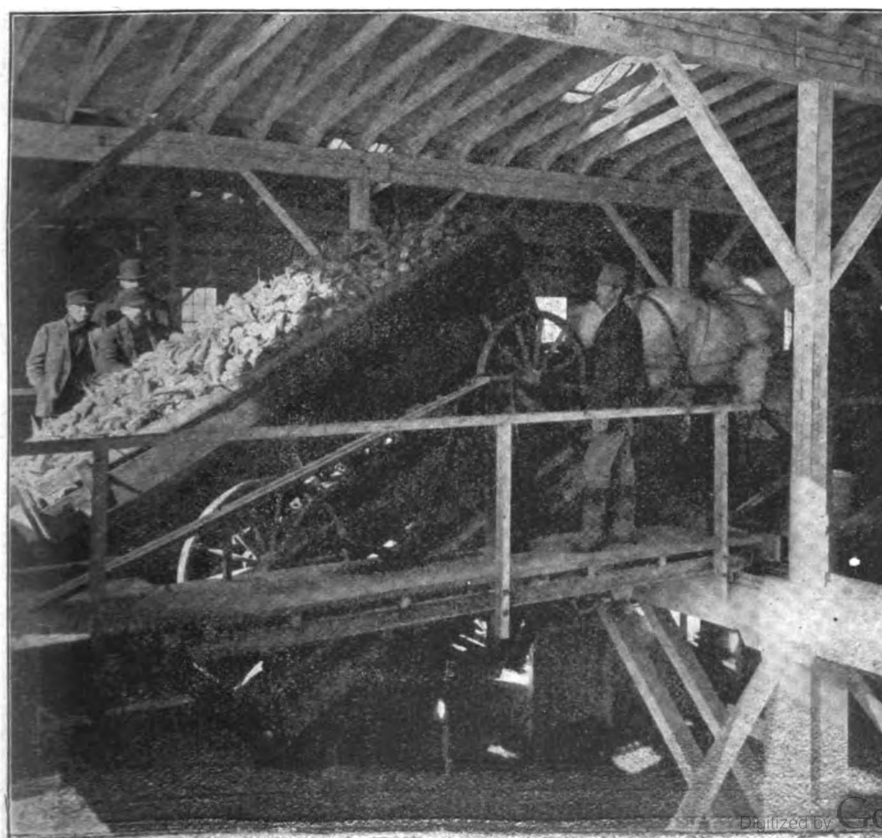

FIGURE 5.—Unloading beets into the factory beet sheds. By this means the wagons are unloaded

nature of sugar beets. In sugar beet culture the factory exercises a wholesome technical control by which we are supplied at once with a means of judging the results of our efforts; for corn and potatoes and even also for wheat the possible inferiority of the product is very often too much neglected.

The essentials of the agriculture of the beet sugar industry must be some time mastered and possible improvements of methods must be applied before the grower will be able to command the situation in a manner at all desirable or acceptable to the progress of the industry. New experiences in the adaptations of his soil, the matters of proper plowing, the better dates for planting and the most profitable rotation to follow, all crowd to the front and demand solution; nor can the final solution be secured in a limited number of years. Sugar beet growing, like corn growing, wheat culture and stock raising, is a matter to be taken with the grasp that contemplates a future of considerable duration and would utilize every feature for knowledge and for profit. The long, strong effort, not the spasmodic effort, will be of most help.

The matters of distance to plant, space in thinning, and cultivation necessary are covered by factory instructions by men of experience. Repetition need not be made here. One point, that of interspaces should perhaps be mentioned, because of previous suggestions favoring small spaces, a thick stand and small beets. It is apparent that this is not a practicable suggestion. The cost of harvesting and topping is increased by it and without adequate return. With 18 or 20 inch rows, thinning to 8 or 10 inches apart gives larger beets and fewer to top; this plan is that followed by the factory agricultural manager. The conditions of success are much the same as in any other line—close study, continued observation and prolonged effort. Most of the really valuable improvements must be worked out with experience in beet growing.

SUBSOILING AND EARLY PLANTING ESSENTIAL FOR BEETS.

Forethought is an invaluable sort of judgment to exercise. Nowhere is this more indispensable than with a crop like sugar beets, in which both yield and quality are liable to be affected. Forethought applies here in selecting the land sufficiently in advance to prepare it by fall plowing, and in any event by subsoiling. This matter of subsoiling has been well presented in a leaflet just issued by the Continental Sugar Co., entitled "First hints on sugar beet culture." The two illustrations appearing herewith are taken from that leaflet by the kind permission of the company. The significance of the illustrations is many fold. The unbroken hard-pan, too often found in firm soils *sets a limit to the volume of water stored in the soil*, as well as a limit to the downward growth of the beets; the land prepared by subsoiling *stores a larger volume of water* against the time of need. It goes without any detailed statement

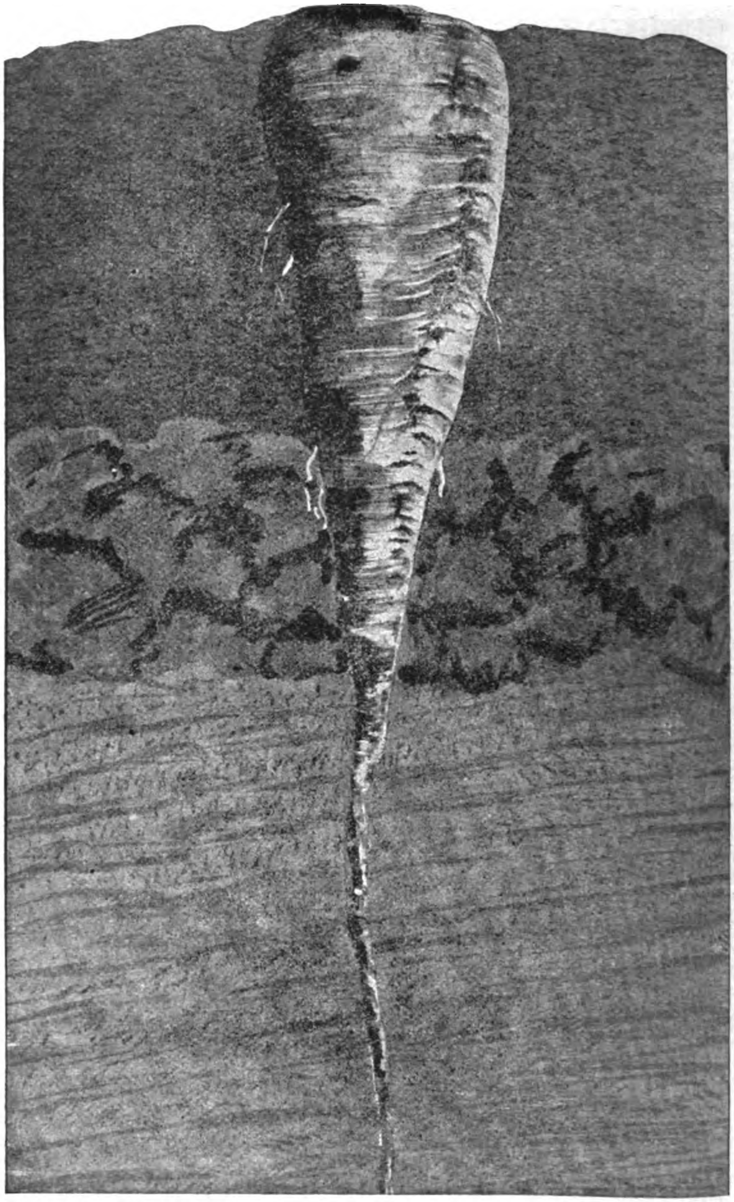

FIGURE 6.—Showing the normal development of the sugar beet in ground properly prepared. Any under-crust, or hardened sub-soil formed by previous handling, has been broken up by subsoiling. The tap-roots of the young beets can then have 14 inches of roots on which to build up the beet instead of 7 inches, as in figure 7. (From cut loaned by the Continental Sugar Company.)

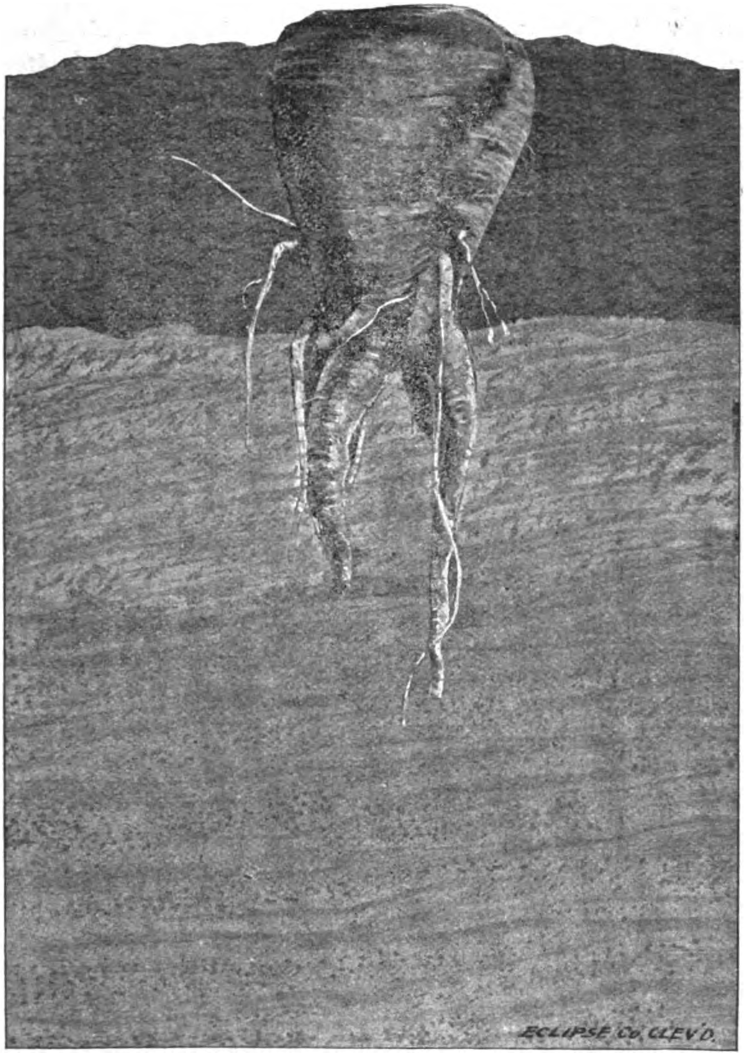

FIGURE 7.—Showing imperfect development of the sugar beet in ordinary 7-inch plowing. Here the tap root has reached the hard-packed, dry soil, which it is unable to penetrate. The root accordingly divides; sends out branches, and in the course of growing the beet is forced out of the ground. The plowing in this case has left an under crust, which is found more impervious than the subsoil below it. (From cut loaned by the Continental Sugar Company.)

of reasons that the plants commanding the greater supply of plant food, and in most equable distribution, will yield the heavier crop. (Figures 6 & 7.)

Fall plowing is invaluable, not alone because of better provision (with subsoiling) for water storage, but *because it makes early planting possible.* No satisfactory results in beet growing can be secured without first having a good stand of beets; early planting, if possible, as early as March, and certainly during April whenever and wherever it can be practiced on suitable beet land, will make for a better stand than late planting. Not only will it do this, but it will result in earlier maturity, other things being equal, and consequently in earlier and more agreeable harvesting and less expensive delivery to cars or factory. I feel assured that a beet grower must determine at an early date where the next year's crop is to be grown, prepare by fall plowing and subsoiling, and that he may not wait to come to a conclusion on these points until he is persuaded to sign a contract for beet growing as the time of planting approaches.

SUGAR BEET DISEASES.

Sugar beet growing is attended by the appearance of certain of the diseases to which this plant is susceptible. The list is, as yet, not a very long one, nor are the damages greater than with older and better known crops. We are prepared now to offer only a brief preliminary discussion of beet diseases; the questions as to beet diseases and their remedies are soon to arise in the course of beet culture.

The diseases of the beet are of various types or classes with respect to the organs attacked, or the effects produced, but broadly speaking they may be said to cause loss to the grower in one, two or three ways:—Either, first, the disease may injure the stand, or the growth of the beets and make a satisfactory crop impossible; or, second, the disease may greatly reduce the sugar content of the beet; or third, as the combined result of the stated influences, notably in the case of leaf diseases of the sugar beet, yield and sugar content may both be unfavorably influenced.

In Europe many diseases attacking the beet have long been known and carefully studied; while it does not follow that the diseases of greatest destructiveness will be the same for both countries, useful lessons may be drawn from European experience. Taking into consideration the beet diseases found in neighboring states, as well as those known to occur in Ohio, we conclude that the beet root is liable to show the effects of root-rot or root-blight, heart-rot or dry-rot, scab, crown gall and bacteriosis, while the leaves may suffer from leaf spot and from the attacks of insects.

ROOT ROT AND DAMPING-OFF (WURZELBRAND.)

The Germans speak of Wurzelbrand, or as we may put it "root-blight," which is a falling of young seedlings, and report upon it in such

a way as to indicate an external variable trouble. Stift[1] passes by the statement of Eidam that the Rizoctonia fungus is an important factor in this disease, but credits it with producing the root-destroying disease, (Würgeltœdter der Rübe) the American root-rot. Pammel[2] supports the observations of both Eidam and Kuehn, as will be seen by his paper; a like interpretation is made by Duggar[3] but with the statement that somewhat of slowness has been observed in the transmission of the beet Rhizoctonia to seedlings of other plants attacked by similar troubles. Duggar treats of this Rhizoctonia fungus in the paper named, more especially in relation to the root-rot of the large beets which he has found in New York. This latter trouble shows its effects later in the season; it affects portions of the beet as shown by the same writer. In growing beet seedlings during the past winter, in the Pathologium of the Botanist of this station, severe damping off has been experienced. The Rhizoctonia fungus has been associated with all the cases so far studied. In view of the recent discovery of the same fungus in great abundance upon potatoes at this Station, growing out of a suggestion by Stewart,[4] as well as its occurrence to a limited extent on sugar beets at harvesting, it would seem necessary to study carefully the disease attributed to it. At present no statements can be made that will indicate the probable losses; the loss on seedlings from this, or similar causes promises to excel those from rotting of large beets.

Remedial measures are, as yet, largely experimental with us. Seed treatment to destroy spores, etc., present in the seed, soil treatment to reach and retard, or destroy, the fungi in the soil, and fertilizer applications, particularly of superphosphates to secure a more vigorous pushing of the seedling beets, have all been supported by good results in particular instances. In Europe, soaking the seed for 20 hours in ½ to 1 per cent solution of carbolic acid, made by dissolving ½ to 1 pound of the given material in 12½ gallons of water, seems to be the commonly recommended seed treatment; after treatment the seed is dried before planting. The same percentages of copper sulfate, and even 2 per cent solutions of the vitrol have been employed in this manner. Either blue vitrol or carbolic acid may be used. Solutions of potassium sulfid, used either by sprinkling or immersion of seed, and the hot water treatment, both essentially the treatments employed for oat smut, have been championed by Jensen for beet seed. The use of Formalin after the method of Bolley is also to be considered.

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[1] Die Krankheiten der Zuckerrübe, Nach den Erfahrungen der Wissenschaft und Praxis, bearbeitet von Anton Stift, Director-Stellvertreter der versuchsstation des Centralvereines fur Rübenzucker-Industrie in der Oesterr-ungar Monarchie. Mit 16 farbigen lithographischen Tafeln. Wien. 1900, p. 14.

[2] Bulletin 15, Iowa Agricultural Experiment Station, pp. 243-25 (1891).

[3] Bulletin 163, Cornell University Agricultural Experiment Station, pp. 346 50 (1899).

[4] F. C. Stewart, New York Experiment Station, Geneva, N. Y., in letter, October 1900.

Liming the soil by moderate applications, specifically stated in most of the foreign papers to be for physiological reasons, such as neutralizing acidity, and supplying calcium oxid, has likewise given good results under particular conditions. The well known work of Halsted[5] on cabbage club root, in which he shows the very great value of quicklime in checking the attacks of the club-root fungus, *Plasmodiophora Brassicæ* Wor. on seedling turnips and on cabbages grown in soil infested by the fungus, as well as the decisive results recently obtained by the writer with quicklime in preventing the attacks of onion smut, *Urocystis Cepulæ* Frost, upon seedling onions, point to the direct effect of fresh lime, in checking parasitic fungi.

Quicklime, applied preferably as the ground lime, just before planting, is worthy of trial for the damping-off troubles often from both points of view, namely, to check fungi and to favor growth of the seedling beets. There is danger, according to European experience, of reduced sugar content in beets by fresh liming.

The use of phosphatic fertilizers is supported by direct experimentation on beets, as with certain other crops. This treatment secures more prompt and more vigorous growth of the seedling beets, at the same time insuring a larger yield. For the seedling troubles it is recommended to be sown as a light application in the furrows with the beet seed; presumably similar effects will arise from previously drilling in or broadcasting, the fertilizer, and larger quantities may be used with safety. We have found acid phosphate less favorable than Thomas slag. The seed treatment and liming, just considered, may be more local in application, especially the former, while the use of acid phosphate, or Thomas slag, will in all probability be generally profitable.

Experiments under glass have been made to test the effects of these various treatments, or fertilizing substances, upon the germination of the beets as well as upon the amount of damping-off under these conditions. To date the results are negative save as to retarding effects of acid phosphate on the seedling beets compared with Thomas slag.

HEART-ROT OR DRY-ROT HERZ-UND TROCKENFÆULE.

This disease, attributed to *Phoma Betae* Frank and to *Sporodesmium putrefaciens*, is one much discussed in Europe. I am not at all certain as to its distribution in Ohio, although diseased beets have been found at Wooster and referred to this trouble in the past season.

The external evidence of the disease consists in the blackening and dying of the central leaves and later in external rotting of the beet; likewise this disease is prevalent during drouth in August and September—hence the two names by which the disease is known.

While some of the older leaves die at the same time, from without, the death of the point of new growth in this disease will serve to distinguish it sharply from the death of the older leaves as a result of leaf-

[5] Bulletin No. 98, New Jersey Agricultural Experiment Station.

spot. As in the case of the death of the leaves from any cause, new leaves soon put out and the sugar percentage in the beet is reduced.

The pycnidia of the fungus may be found upon the surface of the diseased parts in a sufficiently advanced stage; earlier only mycelium is found. Figure seven, Bulletin 121, shows the details as to the pycnidia and spores of the beet Phoma before named.

The claim is made that this heart-rot is propagated by spores which adhere to the seed, and for this reason seed treatment with copper sulfate has been recommended. The heart-rot would also be progagated by successive cropping with beets. Specimens of this trouble would be thankfully received from beet fields in Ohio.

BEET SCAB.

Scab in potatoes has been attributed to a fungus called *Oospora scabies* Thaxter. The same external roughening and similar injurious effects arise from the scab of sugar beets; it has further been shown that it is the same fungus which produces both the scab of potatoes and that of beets. In the case of seed potatoes, treating the seed with corrosive sublimate solution, or with solution of formalin, has proved effective where this seed is planted in scab-free soil. Land that has produced scabby potatoes, or scabby beets, and usually land that has been recently manured, cannot be rated as free from scab. Since for sugar beets we must look to the soil and not to the beet seed for scab infection, prevention of scab lies in avoidance of land that has yielded scabby potatoes, or scabby beets, the previous season; it may also occur that scab will remain a second season in the infected land.

CROWN GALL OF SUGAR BEET.

Both in the plots at the Experiment Station, Wooster, and in the beet fields delivering to the Fremont factory, several cases of this trouble were observed last season. The disease manifests itself as enlargements, or galls, commonly upon the side of the beet near the crown. In Europe this trouble is known under the name of Wurzelkropf (root-craw) and reduces the sugar percentage of affected beets. The analogous appearance of the growths to those occurring on the crown and roots of fruit trees would suggest that the name of crown gall is strictly appropriate. An illustration of a Wooster specimen is presented herewith (Figure 6). While the contagious nature of the disease is to be inferred, experiments are under way to prove the correctness of this inference. The disease will scarcely prove very injurious, though possessing much interest for the investigator. It will be better to avoid planting again immediately in land that has produced the diseased beets.

FIGURE 8.—Sugar beet attacked by crown gall.

BACTERIAL DISEASE, OR BACTERIOSIS OF SUGAR BEET.

Dr. Arthur and Miss Golden early called attention to a bacterial parasite of the sugar beet.[6] A similar disease, or possibly more than one specific bacterial disease of the sugar beet, has been more recently recognized in Europe. The writer has observed diseased beets in Ohio which exhibited the symptoms described as characteristic of this malady. Affected beets show a tendency to corrugation, or buckling in the leaves; the plants grow less vigorously and remain smaller, and usually die back earlier. Upon cutting across a diseased beet the bundles of fibres, which are arranged as concentric rings in the beet root, are found to be darkened and to be much more prominent than in healthy beets. In Europe the common bacteriosis causes dying of the long root tips, and for that reason is called Rubenschwanzfaule, or rot of the root-tip. The sugar content of the beet is also greatly reduced. Mention is made of this disease to call the attention of growers and others who handle sugar beets to the possible prevalence of such symptoms.

LEAF-SPOT OF THE SUGAR BEET.

Judging from its previous abundance, we have in the leaf-spot fungus of the beet, *Cercospora beticola* Sacc., perhaps the most injurious disease producer for our region. A little reflection will indicate how vital good leaves are when we would grow a good yield of good quality beets. That leaves with dead areas, or impaired color, are not good efficient leaves for the work of the plant, likewise, needs only to be stated to be apprehended. Both the growth of the beet root and the percentage of sugar contained in it, are impaired in proportion to the attacks of this disease on the leaf.

As shown by the specimens, the leaf-spot fungus causes usually small, dead areas, commonly very numerous and circular in form, in the leaves of the beet. Each spot may be but a small fraction of an inch in diameter, but has a light colored center, often almost white, with a darker border. The larger spots are often approximately ⅛ inch across, including the border. Ultimately, the affected leaves perish before their time; this is most marked at critical periods, as of prolonged sunshine, etc., just when there is most need for efficient leaves. It is not a natural course of ripening that a large share of the leaves should die, and at times this fungus kills them all in this manner, thus forcing the plant to send out many new leaves. A great danger in this connection is the tendency to regard the death of the beet leaves from the disease as a matter of course, a natural occurrence with the beet.

Just what conditions in detail induce greater abundance of the leaf-spot can scarcely be stated now. Like other fungous diseases, this trouble is worse in showery weather. It has also been observed to be

[6] Bulletin 39, Indiana Experiment Station, 1892.

much worse on soils planted a second time successively in beets. The same disease is rarely absent from garden beets and may therefore be rated as ready to develop when suitable conditions are offered.

Bordeaux mixture sprayed upon the beets has proved very beneficial with garden beets and mangels. Applications may be made as soon as the beets are thinned, but may safely await the appearance of the first spots of this sort, if the growing beets are under close observation. The aim in spraying should be to cover the leaves completely with a fine spray of the preparation, and to repeat at intervals of two to three weeks, until danger is past. The directions contained in the spray calendar, Bulletin 102 or 121, will cover any details of procedure. Rotation of the crop is likely to be required to prevent serious outbreaks of this leaf disease.

RUST AND MILDEW—INSECTS.

White rust, *Cystopus Bliti* (Biv.), Rust, *Uromyces Betae* Tul., and mildew *Peronospora Schactii* Fueckel, are known elsewhere upon the beet, the first having been found in Iowa and the second is prevalent in California; so far as known these have not occurred on sugar beet leaves in Ohio.

The reader is referred to the statements published in Bulletin 99 (1899) concerning the serious losses of beets in 1898 from the broad-striped flea-beetle, a small insect resembling in color-marking, the striped cucumber beetle; the smaller size and fleeing habit will enable one to recognize them. These insects are especially to be feared during dry periods in May and June. Care is required to guard against this pest. Bordeaux mixture should be used freely as a deterrent upon the first appearance of the beetles. Treatment may also be needed a second time if dry weather periods are prolonged.

Bordeaux mixture with arsenites is worthy of trial for the blister beetle; air slaked lime aud Paris green proved an effective remedy on sugar beets at Wooster in 1900. Popular opinion to the contrary, the blister beetles were destroyed by eating leaves dusted with that mixture, one part Paris green to sixteen parts air-slaked lime. Repetition becomes necessary after showers. Flour may be used instead of the air-slaked lime, with which to mix the Paris green or London purple.

SUMMARY.

This bulletin recounts the distribution of about 1,050 pounds of sugar beet seed to 203 persons, situated in 60 counties of Ohio in the Spring of 1900.

It further gives, in Tables IV and V, the results of analyses made at the Station of 303 samples of beets received from 109 persons; of these samples 226 were from the northern section, 57 from the middle and 20 from the southern. See pages 140 to 154.

In Table VI the average results of 1900 are compared with those of 1897, 1898 and 1899; Table VII gives a comparison of varieties tested. See page 154.

Seasonal influences upon the sugar content and purity of the beets grown are considered in Tables II and III and in Figure I. See pages 135, 136, 138.

It is found that periods of comparative drouth and sunshine, having a duration of twenty-five to forty days, are highly favorable to high sugar and good purity when these periods occur between August first and freezing weather: pages 136–8.

It is further discovered that the seasons of 1897 and 1899 were highly favorable, compared with those of 1898 and 1900 in Ohio.

The beet sugar industry is discussed by a brief description of a modern factory and by a consideration of this matter from the grower's side. Illustrations are here introduced.

The sugar beet diseases thus far noted in Ohio are root-blight, or root-rot, heart or dry-rot, scab, crown gall, and bacteriosis, attacking the roots, and leaf-spot attacking the leaves.

Liming the soil intended for beets, preferably in the fall, the application of acid phosphate and Thomas slag with the seed, and the treatment of the beet seed itself with fungicidal substances, are suggested for root-blight and heart-rot.

For scab and bacteriosis it is suggested to avoid infected lands; the same may apply with respect to crown gall.

For leaf-spot it is recommended to use Bordeaux mixture as per the spray calendar, Bulletin No. 102 or No. 121, and to add arsenites for the commoner insect troubles.

PUBLICATIONS OF THE OHIO AGRICULTURAL EXPERIMENT STATION.

Bulletin 120 contains the annual report of the Station for the year ended June 30, 1900, and a list of previous publications. Following are the titles of subsequent issues:

Bulletin 121. A condensed handbook of the diseases of cultivated plants in Ohio.

Bulletin 122. Onion Smut. Preliminary experiments.

Bulletin 123. I, Grape rots in Ohio. II, Experiments in the prevention of grape rot.

Bulletin 124. The maintenance of fertility: Field experiments with fertilizers on corn, oats and wheat, 1899 and 1900.

Bulletin 125. The maintenance of fertility: Field experiments with fertilizers on potatoes, 1894 to 1900.

Bulletin 126. Sugar beet investigations in Ohio in 1900.

Ohio Agricultural Experiment Station.

BULLETIN 127

WOOSTER, OHIO, JUNE, 1901.

MISCELLANEOUS CHEMICAL ANALYSES

OF

FEEDS, FOODS, GRAINS, FRUITS, INSECTICIDES, FERTILIZING MATERIALS' LIMESTONES AND MINERAL WATERS, 1892–1901.

The Bulletins of this Station are sent free to all residents of the State who request them. All correspondence should be addressed to
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NORWALK, O.:
THE LANING COMPANY
1901

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The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 127. JUNE, 1901.

MISCELLANEOUS CHEMICAL ANALYSES

OF FEEDS, FOODS, GRAINS, FRUITS, INSECTICIDES, FERTILIZING MATERIALS, LIMESTONES AND MINERAL WATERS, MADE BY THE CHEMICAL DEPARTMENT DURING THE YEARS 1892–1901.

BY A. D. SELBY AND JOHN W. AMES.

INTRODUCTION.

In the course of the regular chemical work of the Station a large number of analyses have been made to furnish a basis for decision in the several departments interested. Some analyses have also been made at the solicitation of interested parties, a large share of them at the expense of the party desiring analysis.* The number and variety of these analyses may be inferred from the matter of this bulletin; their application, not only at the Station but for interested persons in the state, has suggested the propriety of publication in the manner herein followed.

It has been the endeavor to classify the analyses in such a manner as to facilitate ready reference, while at the same time a separate index to the bulletin is provided.

Chemistry is an exact science and the results of chemical analyses, aside from the small margin of possible error in weights and separations, are to be taken as setting forth the correct composition of the sample in question. It is well to bear in mind that the particular sample analyzed may, or may not, be representative of other similar goods on the market. Only this much may be stated for each analysis—it represents the composition of the particular sample. With respect to the variations in composition some information may be derived by comparing the partic-

*The Ohio Experiment Station has not in the past contemplated gratuitous chemical analysis of substances which have interest only to the discoverers or to the promoters of enterprises. Its work in the chemical line includes investigations bearing on definite lines of Station research. Commercial work is not solicited.

ular analyses with the averages of numerous analyses of the same kind of material made by this Station or by other Experiment Stations of the United States. Such averages have been introduced where of possible advantage. A large part of them are drawn from the publications of the Connecticut, Massachusetts, New Jersey and New York Experiment Stations. Proper credit is given with the citations made.

The stock feeder and prospective purchaser of feeding stuffs must bear in mind that the venders usually have more than one grade of a given material and that the guarantees cover the variations in composition. It is a great advantage to insist on a guarantee as to the composition of material when contracting for purchase, and in our experience it is usually possible to obtain such guarantees when purchase is made of responsible parties. It is further to be borne in mind that the minimum percentage of the guarantee is the only one having force or value to the purchaser; it were better in fact to consider that the minimum is the only guarantee made, for such it really is. A study of the latitude, or variation, between the minimum and maximum percentages stated will usually disclose that these are entirely at the discretion of the guarantor. Guarantees to be of value should be printed or written. An unwillingness to accompany quotations with guarantee of composition may usually be taken as a warning. While in some states statutory provision has been made for the inspection and licensing of concentrated feeding stuffs, much after the manner of that provided for commercial fertilizers, no such provisions now holds in Ohio. Correspondence based on any such assumption must therefore be fruitless.

What has been stated with respect to concentrated feeding stuffs applies with equal, if not greater, force to fertilizing materials. With fertilizing materials there is such a wide variation in composition that mere names are of little significance as to the real value of the materials, which of course is determined by the actual amount of plant food contained in the material in question. At present we recognize that phosphoric acid, nitrogen and potash are the components of value in fertilizing materials; nitrogen is more often calculated to its equivalent ammonia in published analyses. If the analyses in this line are to be of any value to the agricultural public it must be in conveying clearer ideas of the amounts of the components above named found in the substances used. All fertilizing substances are to be judged solely by this standard of composition, taking into consideration, of course, availability as well as quantity of plant food contained. Upon the question of whether it is more profitable to use this or that carrier of phosphoric acid, nitrogen or potash, the published fertilizer experiments of this station will be found to yield the desired information. Farmers will do well to remember that the official control of fertilizers in Ohio is vested in the Secretary of the State Board of Agriculture, Columbus Ohio, and that since this official is in charge of this work the Ohio Experiment Station is released from undertaking analyses of fertilizers. In the official report of the secretary for 1900 the

charges for special analyses have been reduced from $5.00 for each determination, to $3.00 for each determination, as announced therein. Those desiring such special analyses will address the Secretary of the State Board of Agriculture, Columbus, Ohio, and not the Experiment Station.

A limited number of limestones, thought to be rather low in magnesia, have been analyzed during recent years, more especially to discover a suitable stone for use in beet sugar manufacture. A portion of these have already been published in Bulletin 99 but are here again assembled.

The analyses of small fruits were many of them published in the Thirty-Second Annual Report of the State Horticultural Society, 1899.

Some recent distillations of crude petroleum and analyses of insecticides, are likewise included. In this connection the Experiment Station is frèe to confess a greater interest in general commercial products than in any proprietary articles. With the latter the proprietor is especially concerned. The public may, or may not, be benefited by their exploitation.

The analyses contained in this bulletin were made by the various persons who have been connected with the chemical department, F. J. Falkenbach, A. D. Selby, L. M. Bloomfield, J. W. T. Duvel and John W. Ames being responsible for the greater number; certain limestone analyses were made by Mr. R. E. Myers, at one time a student worker in the department. In all cases the name of the analyst is given with the results.

The authors have shared the labor of preparation, and have endeavored to secure correct publication of the records of the department.

I. FEEDS AND FOODS.

1. CORN (MAIZE) AND CORN PRODUCTS.

The composition of maize in the United States is somewhat variable according to source of sample and the variety examined. Our analyses given under "corn meal" show the average composition of the medium-sized, dent variety called Clarage, "grown on the Station farm, omitting other constituents, to be 10.08 per cent. protein, and 3.67 per cent. fat or ether extract. Wiley[1] gives the average of 18 samples from the United States, exhibited at the Columbian Exposition, as protein, 9.88 per cent.; fat (ether extract), 4.17 per cent., and the mean results of a large number of previous analyses by the Department from the United States, protein, 10.39 per cent.; ether extract, 5.20 per cent. The mean of 208 analyses tabulated by Jenkins and Winton[2] is, protein 10.5 per cent., fat 5.4 per cent. The same table gives for 86 dent varieties 10.3 and 5.0 per cent. of protein and fat respectively; and for 68 flint varieties 10.5 and 5.8 per cent. respectively.

[1] Analyses of cereals collected at the World's Columbian Exposition—Bulletin No. 45, Division of Chemistry, U. S. Dept. of Agriculture, p. 25, (1895).

[2] A Compilation of Analyses of American Feeding Stuffs—Bulletin No. 11, Office of Experiment Stations, p. 16 (1892).

The average composition of Ohio grown corn may be inferred from our analyses on page 181. This has already been stated as 10.08 per cent. protein and 3.67 per cent. fat (ether extract).

MAIZE PRODUCTS—WHY CONCENTRATED.

The commercial concentrated feeding stuffs are derived from the original seeds or grains, by the extraction, or separation, of some one, two or more constitutent parts. Thus, with corn, the extraction of the carbohydrates, the starch, gum, etc., in the manufacture of starch or glucose, or in distillery fermentation in the manufacture of fermented liquors and distilled vinegar, leaves a residue of all the unextracted constituents; that is, it leaves these as by-products, or products different from those for which the process of manufacture is designed. In general these particular by-products of corn are composed of the same constituents as the original kernel of the maize *minus* so much of the starchy or fermentable portion as it is found practicable to remove; these residual constituents may be further assorted or separated, so that a great diversity of maize products are upon the market. Hominy manufacture calls for a different modification of the kernels of maize by which the germ and external seed coats are removed; this supplies still another grade of by-product.

Reverting to the by-products or residues from starch and glucose manufacture, it is not difficult to realize how these concentrates show so marked a contrast in composition when compared with the original kernels. This requires only simple calculations based upon the chemical analysis of the kernels and the extent of the extraction. A little discussion will serve to answer the frequent questions on this matter.

Our analyses of Ohio corn show 10.08 per cent. protein, 2.10 per cent. fiber, 3.67 per cent. fat and nearly 70 (exactly 69.76) per cent. of carbohydrates (starch, gum, etc.) classed technically by the chemist as "nitrogen free extract."

Starting with 100 pounds of maize kernels we have:

Weight of kernels 100 pounds or 100 per cent.

Weight of protein contained,	10.08 pounds or	10.08 per cent.
Weight of fiber contained,	2.10 pounds or	2.10 per cent.
Weight of fat contained,	3.67 pounds or	3.67 per cent.
Weight of carbohydrates,	69.76 pounds or	69.76 per cent.

If all the starch, gum, etc., were extracted, about seventy pounds, then the residue would contain:

Weight of residue, 30.24 pounds or 100 per cent.

Weight of protein contained,	10.08 pounds or	33.33 per cent.
Weight of fiber contained,	2.10 pounds or	7.00 per cent.
Weight of fat contained,	3.67 pounds or	12.2 per cent.

The protein, fat and fiber are unchanged by the process employed, but their percentage proportion becomes larger since they are contained in a smaller total weight.

In practice, however, only about fifty pounds of carbohydrates, chiefly starch, will be removed in either starch or glucose manufacture, the first stages of both being the same. The result will then be:

Weight of original kernels, 100 pounds.	
Weight of starch, etc., removed, 50.0 pounds.	
Weight of residue,	50.0 pounds or 100 per cent. of residue.
Weight of protein contained,	10.08 pounds or 20.00 per cent.
Weight of fiber contained,	2.10 pounds or 4.2 per cent.
Weight of fat contained,	3.67 pounds or 7.3 per cent.

It will be discovered, therefore, that there must be considerable assorting and grading of the by-products to put upon the market concentrates showing an average protein content of 25.36 per cent. in Gluten Feed, or even 37 to 39 per cent. protein, as in Gluten Meal.

GLUTEN PRODUCTS.

The following summary by Voorhees and Street[1] will serve to distinguish the several grades of concentrated feeding stuffs from starch and glucose works.

"Gluten meal and the gluten feeds are the residues, or parts of the residues, from the manufacture of starch and glucose. The processes by which the starch is obtained, while perhaps differing somewhat, consist essentially in the separation, first, of the germ and hull from the starch and gluten; and second, the final separation of the gluten from the starch, which is effected by allowing the fluid in which they are suspended to flow through long troughs, the heavier starch settling to the bottom, and the lighter, yellow substance, containing the protein and fat, floating off.

The residue in this manufacture may, therefore, consist either of three products when the gluten, germs and hulls are kept separate, or of mixtures of two of all three of these. In any case, however, the feeds are part of the original corn, though when dried for market they differ in appearance, in proportion of food constituents, and in physical character.

The entire residue mixed together is in color a brighter yellow than corn meal and of a much more bulky character, owing to the presence of a larger proportion of the bran; the trade name of this product is "Gluten Feed." The gluten, by itself, is distinguished by a higher content of protein and a deeper yellow color, and is called "Gluten Meal." The germ is more bulky than the meals, shows a high content of crude fat and is called "Germ Meal." The fat is sometimes extracted, when, similarly to linseed meal, the residue is called "Germ Oil Cake," and, when ground, "Germ Oil Meal." The hulls are very bulky, show a high content of crude fiber, and either alone or with the germ, are sold as "Corn Bran" or "Sugar Feed."

LOWER FAT CONTENT OF RECENT SAMPLES.

It will be observed that the recent analyses of "Gluten Feed" show a reduced percentage of fat; in fact this falls below the fat con-

[1]New Jersey Agricultural Experiment Station, Bulletin 153, pp 41-42 (1901).

tent of the original corn. While not familiar with the technical processes of starch and glucose works, this reduced percentage of the fat in the by-products, would be explained rationally by the general extraction of the oil from the germs. We know that "corn oil" is a product upon the market; no dissatisfaction need attend the appreciation of this lower fat content in gluten feeds if the percentage be as represented.

DISTILLERY AND BREWERY PRODUCTS.

The products from distilleries or breweries which our analyses cover, are entirely from maize. The statements are limited to these waste products. Of the samples analyzed No. 959 was described as "Corn Malt Sprouts." With the exception of its fiber content, which is relatively low, and the percentage of ash, which is high, the sample of Corn Malt Sprouts did not differ greatly in composition from the dried distillery wastes Nos. 1729, 2716 and 2740. Malt Sprouts and Distillers' Grains in the air dry condition have a distinct origin. In the manufacture of beer or whiskey the corn is first caused to sprout, since the growth of this sprout causes more or less change of the starch into sugar; the grain is then dried and the spouts removed by mechanical separation. These short sprouts are the "Corn Malt Sprouts" when maize is used. The "Malt Sprouts" without qualification are such sprouts derived from barley; analyses of these consulted show about one-fifth as much fat and five and one-half per cent. less protein than this sample of "Corn Malt Sprouts." Dried "Distiller's Grains" represent the solid residue from the slops after fermentation—these are the spent grains from the process. When properly dried there is nothing in these grains to indicate an impaired quality in comparison with the like constituents of the original maize. There is valid reason to question the value of the wet grains, particularly if permitted to sour.

CORN (MAIZE) ENSILAGE.

The analyses in the table show the composition of ensilage made from the Red Cob Ensilage variety grown on the Station farm and ensiled in the Station silos. No. 2784 was taken from a silo whose contents were held over during one summer and the following winter. The average water-free substance is one-fifth the ensilage as drawn, (exactly 20.18 per cent. of the whole).

CORN PRODUCTS.

CORN MEAL.

Laboratory No.	208	216	617	628	646	975	976	1694	2563	Average.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Water at 100°	11.17	14.44	10.91	12.63	12.52	14.32	15.34	14.39	11.75	13.05
Ash	1.50	....	1.28	1.28	1.26	1.30	1.33	....	1.44	1 34
Protein	10.00	9.00	11.67	10 36	9.72	8 75	9.18	12 00	10.00	**10 08**
Fiber	....	....	1.89	2.17	1.69	2.30	2.53	....	*5.00	2.10
Fat (ether ex't)	....	....	3 83	3.96	3 21	*1.22	*1 50	3.29	4 06	**3.67**
Carbohydrates	....	....	70.42	69.60	71.60	72.11	70.12	....	67.75	69.76

* Excluded from average.

No. 208—February 1, 1892 (F. J. Falkenbach).
No. 216—March 1, 1892 (F. J. Falkenbach).
No. 617—February 5, 1895 (A. D. Selby and L. M. Bloomfield).
No. 628—March 7, 1895 (A. D. Selby and L. M. Bloomfield).
No. 646—April 27, 1895 (A. D. Selby).
No. 975—January 1, 1898 (A. D. Selby).
No. 976—January 3, 1898 (A. D. Selby).
No. 1694—December 26, 1898 (A. D. Selby).
No. 2563—February 23, 1900 (T. W. Ames).

Numbers 617 to 2563 inclusive were meal made from the clarage variety grown by the Station. These show the composition of the ground corn, without any separation after grinding.

GLUTEN FEED.

Laboratory No.	54	209	616	629	645	979	980	984	1692	2729
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Water at 100°	7.05	7.62	9.36	8.74	6 49	6.91	7.70	6.82	8.39	7.39
Ash	1.30	.84	.83	1.10	.85	2.37	2 60	3.62	....	2.20
Protein†	26.03	28.00	22.18	22.50	23.74	26.25	25.81	26.28	25.19	24.15
Fiber	7.75	....	11.26	9 01	8.35	12.07	13.85	12.05	....	....
Fat (ether ex't)	8 94	....	13.22	13.51	12.14	9.48	3.10	3.05	2.27	4.02
Carbohydrates	48.93	....	43.15	45.14	48.43	42 92	46.94	47.78	....	....

† Protein equal to nitrogen x6.25.

Laboratory No.	Average of Nos. 54–979.	Average of Nos. 980–2729.	Average of 17 recent analyses Buffalo Gluten Feed. (Conn.*)
	Per cent.	Per cent.	Per cent.
Water at 100° C	7.70	7.57	....
Ash	1.21	2.81	....
Protein	**24.80**	**25.36**	**25.66**
Fiber	9.69	12.95	....
Fat (ether extract)	**11.46**	**3.11**	**2.73**
Carbohydrates	48.20	44.86	....

No. 54—From —————— January 24, 1892 (F. J. Falkenbach).

No. 209—From —————— February 1, 1892 (F. J. Falkenbach).

No. 616—From American Glucose Co., February 5, 1895 (A. D. Selby and L. M Bloomfield).

No. 629—From American Glucose Co., March 7, 1895 (A. D. Selby and L. M. Bloomfield).

No. 645—From American Glucose Co., March 25, 1895 (A. D. Selbv and L. M. Bloomfield).

No. 979—From American Glucose Co., December 3, 1897 (A. D. Selby and L. M. Bloomfield).

No. 980—From American Glucose Co., February 3, 1898 (A. D. Selby and L. M. Bloomfield).

No. 981—From American Glucose Co., March 21, 1898 (A. D. Selby and L. M. Bloomfield).

No. 1692—From Glucose Sugar Refining Co., December, 1898 (A. D. Selby).

No. 2729—From Glucose Sugar Refining Co., November 21, 1900 (J. W. Ames).

GLUTEN MEAL.

Laboratory No.	2562	Average of 5 analyses Chicago Gluten Meal. (Conn.*)	Average of 60 recent analyses of same. (Conn.*)
	Per cent.	Per cent.	Per cent.
Water at 100°	7.96	8.65	....
Ash	.96	0.98	....
Protein	39.23	38.70	36.97
Fiber	....	1 97	....
Fat	2.02	3 23	2.98
Carbohydrates	....	46.47	....

No. 2562—From Glucose Sugar Refining Co., February 23, 1900 (J. W. Ames).

GERM MEAL—DISTILLERY PRODUCTS.

	Germ meal.	Hominy meal.	Distillery waste.	Distillery waste "Protegran."	Distillery waste "Protegran."	Corn Malt Sprouts.
Laboratory No.	2575	1757	1729	2716	2740	959
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water at 100°	7.79	....	5.42	7.29	....	7.88
Ash	3.01	....	2 66	2.07	....	5.96
Protein	23.16	53.56	22.39	31 37	30.68	29.09
Fiber	8.62	....	17 34	13.39	....	1.91
Fat	10.37	....	9.59	8.47	10.16	8.97
Carbohydrates	47.05	....	42.60	37.40	....	46.19

No. 2575—From Glucose Sugar Refining Co., February 3, 1901 (J. W. Ames).

No. 1757—From J. W. Kean, Mandale, O., June 9, 1899 (J. W. Ames).

No. 1729—From H. J. Heinz & Co., Pittsburg, Pa., March 20, 1900 (J. W. Duvel). As received this sample contained 77.15 per cent. of water.

No. 2716—From Freiburg & Workum, Cincinnati, O., October 13, 1900 (J. W. Ames).

*Bulletin No. 133, Connecticut Agricultural Experiment Station, 1901.

No. 2740—From Freiburg & Workum, Cincinnati, O., December 29, 1900 (J. W. Ames).

No. 959—From Henry A. Dykins, Cincinnati, O. (L. M. Bloomfield).

Samples No. 959, 2716 and 2740 were the dried product as indicated by the analyses; while technically the samples were "air dried," the actual process of drying is not stated.

ENSILAGE (AIR DRIED).

Laboratory No.	620 (a)	620 (b)	624 (a)	624 (b)	640	981	2576	*2584	Average. 5 samples
	Per ct	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per cent.
Water at 100°	7.01	11.34	8.59	6.40	1.47	6.65	5.93	6.64	6.14
Ash	7.23	4.51	3.08	6.69	7.56	5.91	6.20	6.65	6 08
Protein	7.18	6.71	7.06	7.29	11.98	7.87	9.03	7.95	8.60
Fiber	23.18	15.64	22.47	16.48	26.39	26.47	28.95	29.00	24.14
Fat	6 92	7 11	5.33	6.14	4.09	3.28	2.00	3.09	4.43
Carbohydrates	48.48	54.69	53.47	57.00	48.51	49.82	47.89	46.67	50.61
Original content,									
Water	79.69	79.94	79.78	80.58	79.31	79.55	80.24	76.66	79.82
Dry substance	20.31	20.06	20.22	19.42	20.69	20.45	19.76	23.34	20.18

*Excluded from average.

620 (a) Corn and cob.

620 (b) Fodder sampled from silo, O. A. E. S., February 12, 1895. (A. D. Selby and L. M. Bloomfield.)

624 (a) Fodder
624 (b) Corn and cob } Sampled from silo, O. A. E. S., March 7, 1895.

640—Corn and cob ground together with fodder; sampled April 7, 1895. (A. D. Selby and L. M. Bloomfield.)

981—Run of silo, March 3, 1898; simply fodder, no corn. (L. M. Bloomfield.)

2576—Run of silo, sampled March 10, 1900. (J. W. Ames.)

2584—Ensiled 1898, sampled March 20, 1900. (J. W. Ames.)

These ensilages were all made from red cob ensilage corn.

MAIZE STOVER.

The stalks, blades and husks of the maize after removal of all the grain, are here included as stover. The samples in question represent four series:

First: Samples 621, 623 and 982 made on the dates stated from stores in barn, represent the condition of the stover after being cut up in feed cutter, No. 623 being an analysis of the rejected refuse from the feeding boxes (mangers) and consisting chiefly of the heavier parts of the stalk.

Second: Samples numbered 2565 to 2574, inclusive, were taken from the stover bundles at the time a portion was removed to the barns for further curing. These samples were drawn at the time indicated and stored in packages but were not brought to the laboratory until a few days before those of the third and fourth lots.

Third: The same stover as the second lot with certain additions cured and stored in the barns until sampled.

Fourth: A duplicate set of the same stovers as the third lot but permitted to remain in the field until sampled in March.

In composition, as indicated by the analyses, there is no essential difference. This does not, however, cover the matter of physical constitution or character, which, as we have seen in the case of the corn stover refuse from mangers, Sample No. 623, may determine rather than chemical composition whether certain portions will be rejected by stock. That weather effects from standing in the field cause a large loss due to physical changes, remains yet to be shown.

STOVER COMPARED WITH ENSILAGE.

Compared with air dry ensilage the average composition of these stovers shows about the same water content and ash, above 2½ per cent. less protein, above 7½ per cent. more fiber, 3 per cent. less fat and approximately 2 per cent. less nitrogen free extract or carbohydrates. The advantages in chemical composition are therefore with the ensilage for equal weights of dry substance.

MAIZE STOVER VS. ENSILAGE.

	Stover.	Ensilage.
	Per cent.	Per cent.
Water at 100° C	5.89	6.14
Ash	6.17	6.08
Protein	6.03	8.60
Fiber	31.82	24.14
Fat	1.35	4.43
Carbohydrates	48.74	50.61

It will also be observed that the dry substance of ensilage is higher in protein than the kernels of maize, by our analyses.

MAIZE FODDER—STOVER.

Laboratory No.	Description of sample.	Water at 100°	Ash.	Protein.	Fiber.	Fat.	Carbohydrates.
		Per ct.	Per ct.	Per ct.	Per cent.	Per ct.	Per cent.
621	Cut and stored, samp. Feb. '95..	6 57	5.63	6.63	30.33	2.62	48.22
623	Refuse from mangers, Mar. 10,'95	7.77	5.12	6.39	29.07	2.14	49.51
982	Run of stover, Mar. 31, '98.......	4.61	4.71	5.68	31.48	1.03	52.49
	Average of above, 2 samples.	5.59	5.17	**6.15**	30.91	**1.83**	50.35
	Stover, sampled in Fall, '99.						
2566	Rotation Plot 11, Clarage........	5.57	5.20	7.63	32.33	1.74	47.53
2567	Rotation, Plot 20, Clarage.........	5.93	5.86	6.22	32.63	1.46	47.90
2568	Clarage, variety test..	6 26	5.64	5.78	32.39	1.45	48.48
2565	Hickory King, variety test........	5.07	5.17	7.07	32.67	1.54	48.48
2569	Pride of the North, variety test..	6 43	5.32	5.78	33.37	1.27	47.82
2570	King of the Earlies, variety test..	4.79	6.25	6.33	33 68	1.36	47.59
2571	Improved Leaming, variety test..	5.76	5.73	6.00	32.60	1.31	48.60
2572	White Cap Yellow Dent, variety test.......................................	5.56	5.65	5.14	34.89	1.28	47.48
2573	Early White Dawn, variety test.	5 82	5.42	6.00	32.50	1.35	48 91
2574	Golden Beauty, variety test......	6.18	5.17	7.08	30.46	1.53	49.58
	Average of above 10 samples.	5 74	5.54	**6.30**	32.75	**1.43**	48.24

SAME STOVER CURED INDOORS—SAMPLED MARCH, 1901.

Laboratory No.	Description of sample.	Water at 100°	Ash.	Protein.	Fiber.	Fat.	Carbohydrates.
		Per ct.	Per ct.	Per ct.	Per cent	Per ct.	Per cent.
2587	Rotation, Plot 11, Clarage.........	5 82	6.29	5.06	30.16	1.37	50.80
2589	Rotation, Plot 12, Clarage.........	5.61	6.35	5.14	30.96	1.33	50.61
2591	Rotation, Plot 18, Clarage.........	4.50	8.09	6.89	29.76	1.34	49.42
2593	Rotation, Plot 20, Clarage.........	6.17	8.86	6.00	30.14	1.35	47.48
2595	Clarage, variety test................	6.24	6.71	6.22	30.24	1.12	49.47
2585	Hickory King, variety test........	6.09	4 93	6.22	31 50	1.43	49.83
2597	Pride of the North, variety test	5.90	5.37	6 00	32.75	1.35	48.63
2599	King of the Earlies, variety test	6.83	5.19	5 06	32.82	1.21	48.89
2601	Improved Leaming, variety test	6.96	5.89	5.14	30.76	1.15	50.10
2603	White Cap Yellow Dent, variety test..	5.13	6.71	5.62	32.44	1.27	48.83
2605	Early White Dawn, variety test.	5.52	5.41	5.37	32.46	1.25	49.99
2607	Golden Beauty, variety test.	5.82	5.79	5.87	31.40	1.61	49.51
2609	Early Mastodon, variety test.....	6.98	5.46	5.87	30.81	1.24	49.64
2611	Chester County Mammoth, variety test..................................	6.40	6.44	5.62	31.97	1.17	48 40
	Average of above 14 samples	5.99	6.25	**5.72**	31 29	**1.29**	49 44

Same Stover, field cured,—Sampled March, 1901.

Laboratory No.	Description of sample.	Water at 100°	Ash.	Protein.	Fiber.	Fat.	Carbohydrates.
2588	Rotation, Plot 11, Clarage.........	6.82	7.62	5 36	32.30	1.16	46.74
2590	Rotation, Plot 12, Clarage.........	5.56	7.38	5 77	30 09	1.24	49 96
2592	Rotation, Plot 18, Clarage.........	6.47	7.50	5.56	30.07	1.33	49.07
2594	Rotation, Plot 20, Clarage.........	4.77	7.67	6 89	28.73	1.38	50.56
2596	Clarage, variety test	6.22	6.69	6.22	31 64	1.38	47.85
2586	Hickory King, variety test........	6 36	4.48	6.85	33.32	1.28	47.71
2598	Pride of the North, variety test	6.45	6 85	6.00	30.83	1.42	48.45
2600	King of the Earlies, variety test	5.95	6.37	5.56	32.06	1.32	48.74
2602	Improved Leaming, variety test	5.62	8.51	5.37	30.17	1.14	49.19
2604	White Cap Yellow Dent, variety test.......	6 43	6.19	5.18	32.98	1.21	48.01
2606	Early White Dawn, variety test.	5 36	5.33	7 78	29.65	1.88	50.00
2608	Golden Beauty, variety test.......	5.74	6.31	6.25	31 51	1.41	48 78
2610	Early Mastodon, variety test.....	6.08	7.40	5 18	31.97	1.16	48 21
2612	Chester County Mammoth, variety test..............................	5 32	6.18	6.87	34 36	1.23	46 04
	Average of above 14 samples.	5 94	6.75	**6.06**	31.41	**1.32**	48.52

Nos. 621, 623, 982—By A. D. Selby and L. M. Bloomfield.
Nos. 2585–2612—By J. W. Ames, 1900.

2. HAY.

We present below a few analyses of hay. By comparison with the analyses of stover and ensilage on the preceding pages it will be seen how near these approach the air dry substance of ensilage in protein content and the stover in fiber.

Laboratory No.	622	625	641
	Per cent.	Per cent.	Per cent.
Water at 100°	5.96	6.22	6.37
Ash	6.38	5.00	3.56
Protein	7.50	6.63	10.62
Fiber	35.15	32.79	30.09
Fat	2.82	1.97	2 60
Carbohydrates	42.19	47.39	46.76

622 - Mixed Hay; ⅓ Timothy, ⅔ Clover. Feb. 12, 1895.
625—Mixed Hay; ⅓ Clover, ⅔ Timothy, March 7, 1895.
641—Timothy Hay; March 25, 1895 (A. D. Selby and L. M. Bloomfield).

3. WHEAT AND WHEAT PRODUCTS.

Wheat and wheat products, as here included, refer to winter wheat and the products derived from it—the single exception being with respect to the wheat flours, of whose source we are not informed. The wheat bran included is all believed to belong to the grade known as coarse bran, consisting of the external layer of the grain removed by the processes of modern milling and without admixture of "shorts" or "middlings." The high mineral content, largely phosphates, as indicated by the relatively high percentage of ash as well as the considerable percentage of nitrogen (2.5%) indicated by the protein content of 15.5 per cent, show the fertilizing value of bran at the same time. Compared with the entire grain the bran shows no such concentration of protein as with the gluten products; there is, however, a marked concentration with respect to the ash constituents. A very large number of determinations of water, protein and fat in wheat has been made at this Station during a period of years. The results show no apparent change in composition by reason of the fertilizers applied to the soil on which the wheat was grown. While there are slight differences from year to year these do not appear to be traceable to the manures applied. For 187 analyses the averages are water, 10.49, nitrogen 1.97, protein 12.23 per cent.

Judging by the analyses of low grade and entire wheat flour, which however, are too few to make the case certain, these show a very large advantage over the average of American wheat flours (white) from winter wheat. It does not seem probable that there will be found as a rule much above 2 per cent. more protein in the entire wheat flour compared with white flour from wheat.

WHEAT BRAN.

Laboratory No.	211	219	619	626	642	977	978	2564	2728	Average.
	Per ct.	Per ct.	Per ct.	Per ct	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Water at 100°	9.48	11.36	8.16	9.45	9.41	9.80	10.37	8.89	9.05	9.30
Ash	....	....	5.88	5.59	6.00	5.93	5.79	6.75	5.53	5.97
Protein	16.72	16 20	16.60	17.23	16.50	14.00	13.56	15.54	15.56	15.57
Fiber	....	....	12.19	12.77	8.79	11.46	15.02	9.90	8.66	11.26
Fat (ether ex't)	....	....	3.21	3.14	3.65	3.07	5.30	4 52	3.77	3.82
Carbohydrates	....	....	53.96	51.52	55.65	55.74	49.96	54.40	57 43	54.09

211—Ohio Experiment Station, February 1, 1892 (F. J. Falkenbach).

219—Ohio Experiment Station, March 3, 1892 (F. J. Falkenbach).

619—Ohio Experiment Station, coarse wheat bran, February 5, 1895 (F. J. Falkenbach).

626—Ohio Experiment Station, March 7, 1895 (A. D. Selby and L M. Bloomfield).

642—Ohio Experiment Station, coarse wheat bran, April 7, 1895 (A. D. Selby and L. M. Bloomfield).

977—Ohio Experiment Station, March 3, 1898 (L. M. Bloomfield).

978—Ohio Experiment Station, March 3, 1898 (L. M. Bloomfield).

2564—Experiment Station, February 23, 1900 (J. W. Ames).

2728—Ohio Experiment Station, November 24, 1900 (J. W. Ames).

WHEAT MEAL (ENTIRE GRAIN).

Laboratory No.	210	218	618	627	643	Average.	Average* 262 analysis winter varieties.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.		
Water at 100°	10.61	12.93	8.89	10.65	9.58	9.71	10.05
Ash	....	....	1.57	1.60	1.58	1.58	1.86
Protein	13.40	13.12	13.01	13.70	14.25	13.65	11.80
Fiber	....	....	2.31	2.39	2.19	2.30	1.80
Fat (ether extract)	....	....	1.55	2.02	1.52	1.69	2.10
Carbohydrates	....	....	72.67	69.64	70.88	71.07	72.00

*Jenkins and Winton—Tables.

210—Ohio Experiment Station, February 1, 1892, (F. J. Falkenbach).

218—Ohio Experiment Station, March 1, 1892 (F. J. Falkenbach).

618—Ohio Experiment Station, February 5, 1895 (A. D. Selby and L. M. Bloomfield).

627—Ohio Experiment Station, March 7, 1895 (A. D. Selby and L. M. Bloomfield).

643—Ohio Experiment Station, March 25, 1895 (L. M. Bloomfield).

WHEAT FLOUR.

Laboratory No.	635	974	Average all complete analyses—Jenkins and Winton.
	Per ct.	Per ct.	
Water at 100°	10.99	10.63	12.42
Ash	....	0.92	0.48
Protein	14.56	15.81	10.84
Fiber	.23	....	0.18
Fat	....	1.65	1.09
Carbohydrates	....	....	74.99

635—Lowest grade wheat flour, March 22, 1895 (A. D. Selby and L. M. Bloomfield).

974—Entire wheat flour (Lockport, N. Y. Mills), December, 1898 (A. D. Selby).

II. FRUITS.

The following analyses of strawberries, blackberries, raspberries, red currants, gooseberries and cherries were made in 1898 and the results were given (though in part incomplete at the time) in a paper* read by the Station Chemist before the Ohio State Horticultural Society at its Euclid meeting, December, 1898, and published in the Thirty-second Report of the Society, 1899, pp. 150–154. The analyses of grapes were made in 1901 and are here published for the first time. It will be observed that only partial analyses were made of grapes. All the samples were taken from the Station premises or from trees upon neighboring lots. They represent the composition of these fruits upon the Station farm, at the date specified. The author at that time warned his hearers against expecting too much from chemical analysis, as follows:

"* * * While we can tell you from chemical analysis, that is, from the ratio of acid to sugar, in a measure, whether a given fruit is sweet or sour, to the taste, by other determinations whether it is nutritious or not, and whether or not the fruit production (seed production) is exhaustive to the soil; as yet we cannot easily enter into the field of fruit flavors apart from acid and sugar. The whole problem of fruit flavors is difficult and has not been adequately investigated. I may state, in short, that those peculiar and more or less evanescent flavors which contribute most to our enjoyment in eating fruits, are thought to be caused by the presence of certain, not always apparently single, compound ethers. Thus the odor, or flavor of apples is chiefly due to amyl valerate as well as to nitrous ether, ethyl nitrate; that of quinces, to ethyl pelargonate; that of pineapple to ethyl butyrate; of green gages to ethyl oenanthylate; of mulberry to ethyl subrate; of wintergreens to methyl salicylate; and that of peaches to nitro benzine and benzoic aldehyde. These are relatively simple artificial preparations of the chemist which have the same odor or flavor as the fruits named. But you will be surprised, when I quote to you from Allen (Commercial Organic Analysis, I: 183) that the formula or recipe of Maisch for making strawberry fruit essence, is to take one measure each of methyl salicylate, ethyl nitrate, ethyl formate, five measures each

* The chemical composition of certain small fruits, by A. D. Selby.

of ethyl acetate and ethyl butyrate, three measures of amyl acetate and two measures of amyl butyrate together with two measures of glycerine and 100 measures of liquor (rectified spirit). The list of compound ethers used in preparing raspberry essence includes thirteen besides the glycerine and alcohol. You will readily appreciate perhaps that the detection of these volatile, complex bodies which are further all the while changing in fruits, is the labor of years; no claim is made for such completeness in these analyses.

The determinations include the amount of water, solid material both soluble and insoluble, seeds, acid, sugars, pectins, fiber and ash. The enormous percentages of water found in green fruits will no doubt impress you all. This ranges from 93 per cent. of water in strawberries to 80 per cent., or sometimes less, in raspberries.

It may be observed that the pectins are largely the jelly making bodies. This applies throughout the analyses. Doubtless the most interesting matters pertain to comparison of varieties in respect to acidity." * * *

With respect to the method of analysis the subjoined brief statement will serve as a guide for those interested.* There are many questions which will suggest themselves to the person intensively engaged in the culture of any one or of all these fruits; to anticipate these seems unnecessary, if not impracticable. This may properly be left to those concerned with the testing of varieties and values of fruits.

It is an open secret that in point of dry digestible substance fruits show relatively very low percentages compared with the cereals. Nevertheless they have a very important influence in a dietary, which may be compared with that of recreation and amusement in the body

*METHODS OF FRUIT ANALYSIS.

The methods in general are given in bulletin No. 3, Iowa Experiment Station, 1888.

1. *Moisture and total solids.* One hundred gms. of the fruit were heated in a water oven at 100° and finally in an air bath at 110° to nearly constant weight.

2. *Water soluble solids, reducing sugars, free acid and pectins* were determined in a solution obtained by pulping 100 gms. of fruit in a mortar, extracting the pulp twice with hot water and four times with cold water, allowing thirty minutes for each extraction. The juice thus extracted was strained through a linen filter and the solution made up to a definite volume (1000cc.):

(*a*) *Water soluble solids.* A portion of the extracted juice was filtered and 20cc. transferred to a flat bottomed porcelain dish and dried in a water oven to constant weight.

(*b*) *Reducing sugars.* The extracted juice was clarified with bone black and the sugar determined by means of Fehling's Solution (Soxhlet's Exact Method).

(*c*) *Free acid* was determined in an aliquot portion of the filtered juice, with decinormal soda solution, using phenolphthalein as an indicator.

(*d*) *Pectins soluble in cold water*—50cc. of the filtered juice were evaporated almost to dryness, an excess of 95 per cent. alcohol added, allowed to stand for six hours filtered through a Gooch crucible, washed with alcohol and dried in a water oven to constant weight.

Fiber was determined by the provisional method of the Association of Official Agricultural Chemists.

Protein—The per cent. was obtained by determining the nitrogen by the Kjeldahl method and multiplying the result by 6.25.

Seeds and ash were determined on the dry residue left from the moisture determination.

social. The summaries given of these analyses in the tables render further discussion unnecessary.

It may be stated that the analyses of the grapes were made primarily to determine whether any relation may exist between the composition of the several varieties and their varying susceptibility to rot. The acid and sugar seemed of chief possible influence in this regard; complete analyses were not made, as will be observed by reference to the table. No exact relation was discovered between composition and behavior toward the grape rot—the susceptible varieties apparently differing little from the non-susceptible in composition.

ANALYSIS OF 6 VARIETIES OF STRAWBERRIES TAKEN JUNE 14, 1898.

	Clyde. (994)	Enhance. (995)	Tennessee Prolific. (996)	Greenville. (997)	Haverland. (998)	Warfield. (999)
	Per ct.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	93.84	91.86	92.33	91.94	93.47	92.49
Solids, total	6.66	8.14	7.67	8.06	6.53	7.51
Solids soluble in cold water	3.79	5 24	5.25	5.40	3.74	6.15
Seeds	.65	.71	.78	.50	.65	.59
Free acid	.85	1.25	.99	.92	.79	.92
Reducing sugars	2.32	3.13	3.20	4.16	2.63	3.12
Protein	.52	.69	.84	.56	.56	.52
Pectins	.61	.33	.54	.77	....	.70
Crude fiber	.39	.48	.27	.23	.24	.27
Ash in entire berry	.45	.30	.44	.33	.31	.45
Ash in water soluble solids	.42	.26	.41	.31	.29	.43
Ash in seeds	.01	.02	.01	.01	.01	.01
Protein in seeds	0.47	.07	0.42	.23	.03	0.31
Ratio of acid to sugar	1:2.7	1:2.5	1:3.2	1:4.5	1:3.3	1:3.4

ANALYSIS OF 5 VARIETIES OF STRAWBERRIES TAKEN JUNE 17, 1898.

	Brunette. (1638)	Enormous. (1639)	Brandywine. (1640)	Haverland. (1641)	Warfield. (1642)	Average. 11 varieties.
	Per ct.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	91.56	92.87	92.27	92.81	92.27	92.47
Solids	8.44	7.13	7.73	7.19	7.73	7.53
Solids soluble in cold water	6.10	3 96	3.63	5.71	3.78	4.79
Seeds	1.12	1.58	1.28	1.13	1.42	.95
Free acid	1.20	.94	1.07	.94	1.20	1.01
Reducing sugars	4.18	2.99	2.66	2.69	2.32	3.04
Protein	.76	.67	.87	.55	.76	.66
Pectins	.96	.69	.84	.90	.50	.68
Crude fiber	....	....	....	....	....	.31
Ash in entire berry	.50	.45	.54	.40	.45	.42
Ash in water soluble solids	.55	.33	.45	.34	.44	.38
Ash in seeds	.04	.05	.04	.04	.06	.03
Protein in seeds	....	....	....	....	....	.25
Ratio of acid to sugar	1:3.5	1:3.2	1:2 5	1:2.8	1:2.0	1:3.0

ANALYSIS OF 3 VARIETIES OF RASPBERRIES TAKEN JUNE 28 AND JULY 5, 1898.

	Eureka.		Kansas.		Lotta.	Average of 3 varieties.
	June 29. (1643)	July 5. (1649)	June 29. (1644)	July 5. (1648)	July 5. (1650)	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent	Per cent.
Water	83.94	82.84	82.94	82.59	79.54	82.37
Solids total	16.06	17.16	17.06	17.41	20.46	15.63
Solids soluble in cold water	6.81	9.08	8.14	9.15	10.33	8.70
Seeds	6.81	5.44	8.14	6.71	7.23	6.87
Free acid	1.63	.78	1.69	1.30	.91	1.26
Reducing sugars	4.63	7.14	6.02	6.25	6.67	6.14
Protein	....	1.58	....	1.36	1.68	1.54
Pectins	.49	1.02	.67	1.72	.85	.95
Ash in entire berry	....	.57	....	.54	.66	.59
Ash in seeds	....	.07	....	.13	.10	.10
Ratio of acid to sugar	1:2.8	1:9.5	1:3.6	1:4.8	1:7.3	1:4.9

ANALYSIS OF 1 VARIETY BLACK, 1 PURPLE AND 2 VARIETIES OF RED RASPBERRIES TAKEN JULY 11, 1898.

	Black.	Purple.	Red.		Red—average.
	Gregg. (1652)	Haymaker. (1653).	Cuthbert. (1654)	King. (1655)	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	73.23	82.89	82.75	84.43	83.59
Solids total	26.77	17.11	17.25	15.57	16.41
Solids soluble in cold water	15.47	12.34	14.33	11.56	12.95
Seeds	3.14	2.33	2.27	2.12	2.19
Free acid	.91	1.56	1.56	1.69	1.63
Reducing sugars	7.93	8.06	8.20	8.20	8.20
Protein	1.41	1.18	1.12	1.36	1.24
Pectins	1.17	.73	1.95	.85	1.40
Crude fiber	.21	.23	.30	.15	.23
Ash in entire berry	.81	.53	.48	.52	.50
Ash in seeds	.07	.05	.05	.05	.05
Ratio of acid to sugar	1:8.7	1:5.2	1:5.2	1:4.8	1:5.0

ANALYSIS OF 4 VARIETIES OF CURRANTS TAKEN JULY 12, 1898.

	Cherry currant. (1656)	North Star currant. (1657)	Red Dutch (1658)	Reds average.	White grape. (1659)
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	85.88	85.28	85.50	85.55	84.71
Solids	14.12	14.72	14 50	14.45	15.29
Solids soluble in cold water	8.98	11.16	10.30	10.31	12.95
Seeds	1.52	....	1.65	1.58	1.26
Free acid	2.60	2.86	2.73	2.73	2.60
Reducing sugars	6.33	7.81	6.33	6.82	8.06
Protein	1.30	1.23	1.10	1.21	1.30
Pectins	1.09	1.23	1.19	1.17	....
Crude fiber	.39	.37	.47	.41	.31
Ash in entire berry	.57	.57	.66	.60	.60
Ash in seeds	.03	.03	.03	.03	.02
Ratio of acid to sugar	1:2.4	1:2.7	1:2.3	1:2.5	1:3.1

ANALYSIS OF 3 VARIETIES OF GOOSEBERRIES AND OF 2 VARIETIES OF BLACKBERRIES TAKEN JULY 23, 1898.

	Gooseberries.			Blackberries.	
	Industry. (1660)	Chautauqua. (1661)	Pearl. (1662)	Eldorado (1663)	Snyder. (1664)
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	85.72	85.34	88.25	85.46	85.60
Solids	14.28	14.66	11.75	14.54	14.40
Solids soluble in cold water	11.67	13.47	11.54	8.63	9.11
Seeds	1.39	1.58	1.25	3.44	3.67
Free acid	1.45	1.33	2.06	.85	.97
Reducing sugars	4.39	4.55	3.25	7.25	7.69
Protein	.70	.84	.68	1.28	1.24
Pectins	.27	.80	.28	....	....
Crude fiber	.38	.49	.42	.43	.33
Ash in entire berry	.30	.32	.37	.41	.26
Ash in seeds	.04	.05	.05	.08	.01
Ratio of acid to sugar	1:3.0	1:3.4	1:1.6	1:8.5	1:7.9

ANALYSIS OF 3 VARIETIES OF CHERRIES TAKEN JUNE 29 AND JULY 5, 1898.

	Montmorency.		Early Richmond.	White Spanish.
	June 29. (1645)	July 5. (1651)	June 29. (1646)	June 29. (1647)
	Per cent.	Per cent.	Per cent.	Per cent.
Water	82.70	82.07	80.40	81.44
Solids total	17.30	17.93	19.60	18.56
Solids soluble in cold water	10.40	11.29	10.54	11.57
Seeds	5.51	5.20	5.45	5.55
Free acid	1.43	1.17	1.82	1.17
Reducing sugars	7.14	6.67	8.33	9.09
Protein	1.43	1.37	2.05	1.72
Pectins	.47	....	1.71	....
Crude fiber	....	....	....	....
Ash in entire berry	....	....	....	....
Ash in seeds	.06	.05	.05	.06
Ratio of acid to sugar	1:5.0	1:5.7	1:4.6	1:7.7

AVERAGE ANALYSES OF STRAWBERRIES, BLACKBERRIES, RED RASPBERRIES, BLACK RASPBERRIES, RED CURRANTS, GOOSEBERRIES, CHERRIES AND GRAPES COMPARED.

	Strawberries.	Black raspberries.	Red raspberries.	Blackberries.	Red currants.	Gooseberries.	Sour cherries.	Grapes.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Water	92.47	82.37	83 59	85.53	81.55	86.44	81 65	79.74
Solids total	7.13	15.63	16.41	14.47	14.41	13.16	18.31	20.26
Solids soluble in cold water	4.79	8.70	12.95	8.87	10.31	12.23	10.95	88.49
Seeds	.95	6.87	2.19	3.55	1.58	1.41	5.18	3.50
Free acid	1.01	1.26	1.63	.91	2.73	1.61	1.39	.15
Reducing sugars	3.04	6.14	8.20	7.47	6.82	4.06	7.80	12.85
Protein	.66	1.54	1.24	1.26	1.21	.74	1.64	....
Pectins	.68	.95	1.40	....	1.17	.45	1.09	....
Crude fiber	.31	....	.23	.38	.41	.43	....	....
Ash in entire berry	.42	.59	.50	.33	.60	.33	....	....
Ash in water soluble solids	.38	....	....	....	....	....	....	....
Ash in seeds	.03	.10	.05	.04	.03	.05	.05	....
Protein in seeds	.25	....	....	....	....	....	....	....
Ratio of acid to sugar	1:3.0	1:5.3	1:5.0	1:8.3	1:2.5	1:2.5	1:5.0	1:8.5

Analyses by J. W. Ames, J. W. T. Duvel and R. E. Myers.

ANALYSIS OF 10 VARIETIES OF GRAPES TAKEN OCTOBER 5, 1901.

	Dela-ware. (3208)	Catawba (3209)	Rock-wood. (3210)	Wood-ruff Red (3211)	Niag-ara. (3212)	Worden (3213)
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water, loss at 100° C	73.29	86.86	77.45	75.29	82.65	83.26
Solids, total	26.71	13.14	22.55	24.71	17.35	16.74
Solids, soluble in cold water	13.15	10.97	9.67	8.14	3.37	12.22
Seeds	3.48	4.57	4 20	3.12	2.47	2.25
Acid as Tartaric	.12	.25	.12	.16	.19	.17
Reducing sugars	15 08	12.62	15.55	11.00	13.00	7.35
Ratio of acid to sugar	1:12.5	1:8.3	1:12.9	1:6.8	1:7.0	1:4.3

	Green Moun-tain. (3214)	Agawan (3215)	Concord (3216)	Ives. (3217)	Average 10 Vari-eties.
	Per cent	Per cent.	Per cent.	Per cent.	Per cent.
Water, loss at 100° C	75.86	79.43	82.33	81.00	79.74
Solids, total	24.14	20.57	17.69	19.00	20.26
Solids, water soluble	7.45	6.28	4.11	9.53	8.49
Seeds	3.08	3.98	4.10	3.78	3.50
Acid, as Tartaric	.06	.21	.11	.12	.15
Reducing sugars	15.55	13.05	12.16	13.11	12.85
Ratio of acid to sugar	1:25.9	1:6.2	1:11.0	1:11.0	1:8.5

From vineyard Ohio Experiment Station, Wooster. Analysis by J. W. Ames.

III. INSECTICIDES.

LEAD ARSENATE—ARSENATE OF LEAD.

Analyses have been made of both the proprietary arsenate of lead which is sold under the name of "Disparene," and of that sold under the chemical name "Arsenate of Lead." The value of these compounds, other things being equal, will be in proportion to amounts of lead arsenate contained; moisture appears inseparable from this lead compound under ordinary methods of preparation. Free arsenic pentoxide would scarcely exist, but the pentoxide would be expected rather to be present as sodium arsenate.

Arsenate of lead has been before the public for several years, beginning with its proposal by Moulton in 1892. It has been made conspicuous in the work of the Massachusetts Gypsy Moth Commission, in connection with which it was first proposed. The following is a condensed

statement of the method of preparing lead arsenate, based upon that given by Frederick J. Smith, in the report of the Gypsy Moth Commission for 1897, printed in "Agriculture of Massachusetts, 1897," pp. 357–369:

Arsenate of lead may be prepared by mixing a solution of either lead acetate ($Pb\ C_2\ H_3\ O_2$), or lead nitrate $Pb\ (No_3)_2$ with a solution of arsenate of soda ($Na_2\ HAs\ O_4$). When acetate of lead is used the arsenate of lead obtained is the triplumbic arsenate, $Pb_3\ (As\ O_4)_2$. The reaction which takes place between acetate of lead and arsenate of soda in solution yields lead arsenate, sodium acetate, and acetic acid, all in presence of water. One part of arsenate of lead requires .74416 parts lead oxide (Pb O) and .2558 parts arsenic pentoxide ($As_2\ O_5$), but experience shows the need to use .77812 parts of lead oxid.

Expressed in avoirdupois pounds, 1 pound 8½ ounces acetate of lead and 10¼ ounces arsenate of soda would be required to make one pound of arsenate of lead.

Where nitrate of lead is used in place of acetate of lead, the reaction taking place yields lead arsenate with sodium nitrate and nitric acid:

One part of lead arsenate $Pb_5\ H_2\ (As\ O_4)_4$ requires .70 parts lead oxide (Pb O) and .30 parts of arsenic pentoxide ($As_2\ O_5$), while experience teaches the need of .7914 lead oxide to precipitate all the arsenic.

Expressed in avoirdupois pounds—1 pound, 2¾ ounces nitrate of lead and 12 ounces arsenate of soda are required for one pound of arsenate of lead.

One pound of acetate of lead dissolves in about one gallon of water, and arsenate of soda dissolves at the rate of one pound to three quarts of water. The salts should be dissolved separately in *wooden vessels* and the solution poured into a tank partially filled with water. The arsenate of lead will separate as a fine, white precipitate; the supernatant fluid may be removed by siphon.

It may be added that in practice in Massachusetts it was found advantageous to precipitate the arsenate of lead in the spray tank by combining the solutions of lead acetate and sodium arsenate in the tank when ready to use.

The information above given may prove insufficient; should any desire to make his own lead arsenate, tables six and seven, page 369 of "Agriculture of Massachusetts, 1897," contain tables for various weights of ordinary grades of the chemicals to use for making the several amounts of lead arsenate. Where these are accessible they will be helpful. The weights quoted are from the tables in question. They are based upon "white granulated acetate of lead" and "65 per cent. arsenate of soda" and upon average nitrate of lead and the same grade of arsenate of soda (65 per cent.).

ARSENATE OF LEAD.

Laboratory No.	3156 (Disparene)		3157 (Arsenate of Lead.)	
	Original sample.	Calculated water free sample.	Original sample.	Calculated water free sample.
	Per cent.	Per cent.	Per cent.	Per cent.
Moisture at 100°	40.40	....	36.64	....
Lead Oxide PbO	38.50	64.30	39.14	61.76
Arsenic Pentoxide As_2O_5	13.28	22.28	14.83	23.37
Equivalent Arsenate of Lead ($Pb_3(AsO_4)_2$)	51.73	86.40	52.59	82.99
Excess Arsenic Pentoxide (Probably combined with sodium)	.05	.10	1.38	2.15

3156—From Ohio Farmer, manufactured by the Bowker Chemical Co., Boston, Mass., May 25, 1901. (J. W. Ames.)

3157—From Swift & Co., Boston, Mass., May 25, 1901. (J. W. Ames.)

PARIS GREEN.

In the terms of the chemist, Paris green or Scheele's green is a copper aceto-arsenite containing, as stated by Van Slyke,* when entirely free from extraneous matter, the following constituents:

Copper Oxide .... 31.30 per cent.
Arsenious Oxide (As_2O_3) .... 58.64 per cent.
Acetic Acid .... 10.06 per cent.

As a rule this theoretical composition is not attained; the analyses given show how nearly good grades of Paris green approach this composition. The deficiency in acetic acid is thought to be rather unimportant—Those of copper oxide and arsenious oxide (arsenic trioxide) being the important constituents. Adulteration is usually by the addition of arsenic trioxide, which would in that case be unaccompanied by copper.

PARIS GREEN.

Laboratory No.	Theoretical composition. (Van Slyke.)	2677	2672	Average 22 samples, N. Y. B. 190 (Van Slyke).
	Per cent.	Per cent.	Per cent.	Per cent.
Copper Oxide	31.30	30.92	28.95	28.97
Arsenious Oxide	58.64	58.53	58.99	57.05
Acetic Acid	10.06	8.00	7.50	....

2672. Sampled at Northwestern Substation, Neapolis, July, 1901 (J. W. Ames).
2677. From Laubach & Boyd, Wooster, O., July, 1901 (J. W. Ames).

* Bulletin 190, New York Agricultural Experiment Station, 1900.

CRUDE PETROLEUM—CRUDE OIL.

Recently, in the treatment for scale insects, the use of refined oil or kerosene and crude petroleum have become widespread. The call for examination of samples has been met by the distillations which follow. For use without dilution the oils of lower specific gravities, say 44° to 46° Baumé, have been found safer. For application in connection with water when the oil constitutes 20 to 25 per cent., or less of the mechanical mixture, there appears to be no objection to the use of the heavier oils which, like these given in numbers 2631 and 2632, have a specific gravity of 34° and 35° Baumé. It may be remarked that when higher temperatures than 250°C. are employed in the distillations the oils are "cracked" or become split up in such a way as to yield afterwards considerable distillates, even at lower temperatures. The lighter oils contain higher percentages of the "Benzine" and "Naptha" or lighter grades, and less residue than the heavier oils.

Samples Nos. 2631 and 2632 are both black oils; No. 2768 is an amber colored oil and No. 3158 an olive or green oil. The first two approach Lima oil in grade; the last two grade as Pennsylvania oil on the market.

CRUDE PETROLEUM DISTILLATIONS.

Laboratory No.	2631	2632	2768
	Per cent.	Per cent	Per cent.
Specific gravity, (degrees Baumè)	35° B.	34° B.	45° B.
Light Naptha, 80° C.	1.49	.14	1.89
Heavy Naptha, 120°	4.35	1.63	9.26
Benzine, 150°	5.03	3.82	9.04
Light burning oil, 150°–200°	7.64	13.48	10.73
Heavy burning oil, 200°–250°	13.54	12.03	15.80
Residue, 250°+	68.70	68.62	53.28
Residue, 250° redistilled to 315° distillate	....	....	45.60
Residue, 315°+	....	....	7.70

2631. From Lodi, O., May 16, 1900 (J. W. Ames).
2032. From Gypsum, O., May 16, 1900 (J. W. Ames).
2768. Scio oil, Sun Oil Co., Toledo, O., April 1, 1901 (J. W. Ames).

CRUDE PETROLEUM DISTILLATIONS.

Laboratory No.	3154	
	Per cent.	
Specific gravity	45° B.	
—50° C	.85	
Petroleum ether, 50°–70°	2.06	
Gasoline, 70°–90°	1.00	
Naptha, 90°–120°	5.12	
Benzine, 120°–150°	5.35	
Illuminating oils, 150°–200°	13.70	
Illuminating oils, 200°–250°	12.49	
Illuminating oils, 250°–300°	17.76	58.67 per cent. residue at 250° C.
Illuminating oils, 300°–315°	23.93	
Residue, 315°+	16.98	

3154. From Chester Hill, Morgan Co., O., May 24, 1901 (J. W. Ames).

IV. FERTILIZING MATERIALS.

Fertilizing materials in the sense here used are such as supply the elements of plant food, namely, nitrogen, phosphoric acid and potash. These are in part carriers of a single element of plant food, as of nitrogen only, of phosphoric acid only or of potash only; we have also carriers of two elements and carriers of all three elements, the last of which we are accustomed to designate as complete fertilizers. Possibly this term is unfortunate, since "complete" should signify the right proportion as well as the presence of all the elements of plant food. The materials we purchase are bought to supply, therefore, some one, any two or all three of these elements. Everything of this sort should be purchased on the basis of guaranteed composition.

The materials containing nitrogen alone are Dried Blood, Nitrate of Soda, Sulfate of Ammonia, Hoof Meal, Azotin, etc.

Those containing phosphoric acid alone are Bone Black, Phosphate Rocks, Apatite, Acid Phosphate, Thomas Slag.

Those containing potash alone are the Potash salts of the German Syndicate, Sulfate of Potash, Muriate (Chloride) of Potash, Kainit, etc.

On the other hand a number contain both nitrogen and phosphoric acid. Of these are Bone, both raw and steamed, Tankage and in a sense certain mill products such as wheat bran, cotton seed meal, linseed meal; these latter contain small percentages of potash as well. The ashes of plants and plant remains, such as wood, corn cobs, coal and the like, contain both phosphoric acid and potash. Those mater als containing all three elements are prepared for the most part by mixing the others. The manures are an exception here. For fuller discussion of these elements and their nature, the reader is referred to the bulletins dealing with fertilizers. Nos. 93 and 100 deal with the "Home Mixing of Fertilizers" and Nos. 71, 94, 110, 124 and 125 with the "Maintenance of Fertility." The relative availability of the plant food in the several carriers is exhibited in Bulletin 110.

CARRIERS OF NITROGEN.

Of those enumerated we give analyses of three, Dried Blood, Sulfate of Ammonia and Nitrate of Soda. The average composition is indicated along with the results of analysis. The value of these is determined by the nitrogen contained, or by its equivalent, ammonia. To obtain the percentage of ammonia from that of the nitrogen, multiply by 1.214 and conversely multiply the percentage of ammonia by .825 to obtain the per cent. of nitrogen. The percentages given enable one to calculate the number of pounds of nitrogen, or its equivalent, ammonia, in each 100 pounds, or in each ton of the given material. The nitrogen in each sort of material does not yield the same results in field practice; in other words the nitrogen is not equally available. Director Thorne has calculated the availabilities of nitrogen in the several carriers, Bulletin 110, page 65, to be as follows:

Nitrate of soda (the standard)	100
Sulfate of ammonia	86
Dried blood	82
Linseed oil-meal	79

Hoof meal furnishes nitrogen in a much less available form than those enumerated; the same applies to leather scrap, wool waste and some other materials.

With respect to nitrogen in tankage, field tests indicate an availability very nearly the same as for dried blood; wheat bran and cotton seed meal rank very close to linseed meal in the availability of the contained nitrogen.

DRIED BLOOD.

Laboratory No.	747	986	1674	1759	2713	2670
	Per ct.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Nitrogen	8.05	13.57	12.20	13.29	13.09	13.81
Nitrogen equivalent to ammonia.	9.06	16.48	14.81	16.14	16.50	16.84

747—June 20, 1896 (L. M. Bloomfield).
986—March 21, 1898 (L. M. Bloomfield).
1674—October 10, 1898 (J. W. Duvel).
1759—From Association of Official Agricultural Chemists, 1899 (J. W. Ames).
2713—From Association of Official Agricultural Chemists, 1900 (J. W. Ames).
2670—June 24, 1900 (J. W. Ames).

NITRATE OF SODA, SODIUM NITRATE.

Laboratory No.	740	749	2762
	Per cent.	Per cent.	Per cent.
Moisture	3.50	1.21	2.10
Nitrogen	**11.06**	**12.46**	**12.05**
" Equivalent to ammonia	13.42	15.13	14.62

740—Ohio Experiment Station, June 26, 1896 (L. M. Bloomfield).
749—Ohio Experiment Station, June 22, 1896 (L. M. Bloomfield).
2762—Ohio Experiment Station, March 31, 1901 (J. W. Ames).

SULFATE OF AMMONIA, AMMONIUM SULFATE.

Laboratory No.	741	922
	Per cent.	Per cent.
Moisture	2.07	....
Nitrogen	**19.04**	**20.00**
" Equivalent to ammonia	23.11	24.28

741—Ohio Experiment Station, June 22, 1896 (L. M. Bloomfield).
922—Ohio Experiment Station, 1897 (L. M. Bloomfield).

CARRIERS OF PHOSPHORIC ACID.

In Bulletin 110, from which we have already quoted, on page 67, the availability of phosphoric acid in the several carriers is computed to be as follows:

Thomas or Basic slag	100
Dissolved bone-black	96
Raw bone meal	87
Acid phosphate	87

A number of these carriers have been analyzed and the results are given. They include acid phosphate, Thomas slag, dissolved bone-black, phosphate rock and among double carriers, raw and steamed bone, tankage, wood and coal ashes. The fertilizing constituents of linseed meal, wheat bran and cotton seed meal are also indicated.

It will be observed that the results of analyses of bone are in part stated on the same basis as that used for treated or acidulated goods. This was employed to secure, if possible, further light on the relative availability of the phosphoric acid in raw and steamed bone, and in finely ground versus coarse tankage or bone.

Tankage is sold on the basis of its "ammonia" and "bone phosphate of lime" content, and tankages are named by these percentages. Thus a "7 and 30" tankage is one containing 7 per cent. of ammonia

and 30 per cent. bone phosphate of lime; a "9 and 20" tankage is one with 9 per cent. ammonia and 20 per cent. bone phosphate of lime. The same applies to a 6 and 40 and 5 and 20, etc.

The equivalent per cent. of bone phosphate of lime is obtained by multiplying the per cent. of total phosphoric acid by 2.183 and conversely the per cent. of phosphoric acid is derived from that of the bone phosphate of lime by dividing by this factor or by multiplying by .458; the shorter factors 2.18 and .46 give results of approximate accuracy. Thus a 7 and 30 tankage should show 7 per cent. ammonia and $30 \div 2.183 =$ 3 .74 per cent. phosphoric acid or $30 \times .458 = 13.74$ per cent.

In the manufacture of acid phosphates from raw, rock phosphates an equal weight of sulfuric acid is commonly added; this reduces consequently the percentage of total phosphoric acid in the acid phosphate to about one-half that in the floats or raw phosphate rock.

In South Carolina rock, therefore, of 59 per cent. bone phosphate of lime grade, there is to start with but $59 \div 2.18 = 27+$ per cent. phosphoric acid obtainable. A 14 per cent. acid phosphate is the usual grade from Carolina rock; from the higher grade, Tennessee rock phosphates, higher grades of acid phosphates may be obtained.

BONE BLACK AND DISSOLVED BONE BLACK.

	Bone black (untreated).	Dissolved bone black.				
Laboratory No.	921	633	744	959	2725	Average, 2 samples.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Phosphoric acid, total	30.59	25.20	20.80	15.46	18.84	17.15
" " Insoluble	....	14 51	8.84	....	.70	.70
" " Water soluble	....	4.27	5.59	14 85	12.30	13.58
" " Available	....	10.69	11.96	....	18.14	....

921—March 3, 1887 (L. M. Bloomfield).
633—September, 1894 (L. M. Bloomfield).
744—June 22, 1896 (L. M. Bloomfield).
959—October, 1897 (L. M. Bloomfield).
2725—From Michigan Carbon Works, December 15, 1900 (J. W. Ames).

Samples No. 633, No. 744 and No. 959 show the gradations in available phosphoric acid arising from incomplete and complete conversion of the insoluble into available phosphoric acid by the use of sulfuric acid. It seems to be a practice with some fertilizer works to treat with but part of the total sulfuric acid necessary, since the goods is thus left without stickiness. Sample No. 959 is the same goods as No. 921, but after proper treatment to make it truly "dissolved bone black."

THOMAS SLAG, OR SLAG PHOSPHATE.

Laboratory No.	989	1764	1765	2718
	Per cent.	Per cent.	Per cent.	Per cent.
Total phosphoric acid	16.76	15.47	16.82	17.62
Insoluble phosphoric acid	3.09	....	....	....
Available phosphoric acid	13.67	13.32	11.47	....

989—Stock O. A. E. S., March, 1898 (A. D. Selby).

1764—European slag from Official Association of Agricultural Chemists, 1899 (J. W. Ames).

1765—American slag from Official Association of Agricultural Chemists, 1899 (J. W. Ames).

2718—American slag from Official Association of Agricultural Chemists, 1900 (J. W. Ames).

ACID PHOSPHATE.

Laboratory No.	745	746	952	954	988	991
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Total phosphoric acid	19.65	16.64	11.44	....	15.75	15.79
Insoluble phosphoric acid	....	....	1.12	.78	3 06	....
Water soluble phosphoric acid	....	10.40	8.77	8.56	10.65	....
Available phosphoric acid	....	....	10.32	....	12.69	13 29

Laboratory No.	992	1670	1673	1741	2652	2721	2726	2765	2617
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent,
Total phosphoric acid	14.36	13.03	16.80	15.77	15.81	17.14	18.42	16.73	16.48
Insoluble phosphoric acid	....	.08	....	1.40	1.27	1.51	1.70	1.42	3.02
Water soluble phosphoric acid	....	....	11.23	12.73	....	11.41	12.14	9.51	13.46
Available phosphoric acid	12.11	12.95	15.61	14.37	14.54	15.57	16.72	15.31	....

745—June 22, 1896 (L. M. Bloomfield).

746—June 22, 1896 (L. M. Bloomfield).

952—Horsehead acid phosphate from Cleveland Dryer Co., October 4, 1897 (L. M. Bloomfield).

954—Horsehead acid phosphate from Cleveland Dryer Co, October 4, 1897 (L. M. Bloomfield).

988—March, 1898 (A. D. Selby).

991—From Powell & Co., May 20, 1898 (L. M. Bloomfield).

992—From Herrick & Haus, May 20, 1898 (L. M. Bloomfield).

1670—From Millsom Rendering and Fertilizer Co., Buffalo, N. Y., October 25, 1898 (A. D. Selby).

1673—From Jarecki Chemical Co., Sandusky, O., October 20, 1898 (A. D. Selby).

1675—From Bowker Fertilizer Co., Boston Mass., October 25, 1898 (A. D. Selby).

1741—From American Fertilizer Co., May 5, 1899 (J. W. Ames).

2652—From U. S. Fertilizer Co., Wheeling, W. Va., per C. G. Chapman, Marlboro, O., June 27, 1900 (J. W. Ames).

2721—From Seneca Fertilizer Works, Tiffin, O., December 15, 1900 (J. W. Ames).

2726—From Swift & Co., Chicago, Ill., December 15, 1900 (J. W. Ames.)

2765—From Armour Co., Chicago, Ill., April 1, 1901 (J. W. Ames).

2617—From Bucyrus Fert. Co., Bucyrus, O., per Peter Conrad, Smithville, O., May 22, 1900.

FLOATS, OR RAW PHOSPHATE ROCK.

Laboratory No.	750	1766	2717*	2719
	Per cent.	Per cent.	Per cent.	Per cent.
Total phosphoric acid	26.16	26.21	14.33	27.02

750—Raw South Carolina Rock, June 22, 1896 (L. L. Bloomfield).

1766—Ground Phosphate Rock from Official Association of Agricultural Chemists, 1899 (J. W. Ames).

2717*—Ground Phosphate Rock from Official Association of Agricultural Chemists, 1889 (J. W. Ames).

2719—Ground Phosphate Rock from Official Association of Agricultural Chemists, 1900 (J. W. Ames).

*Apparently a low grade rock.

FLORIDA SOFT PHOSPHATE ROCK, SO-CALLED NATURAL PLANT FOOD.

Laboratory No.	738
	Per cent.
Phosphoric acid total	26.74
Insoluble phosphoric acid	25.50
Available phosphoric acid	1.24

From Natural Plant Food Co., Richmond, Va., February, 1896 (L. M. Bloomfield).

POTASH SALTS.

The only analyses are those of the potassium chloride, the socalled muriate of potash of commerce. These salts are never pure, but are sold on a basis of 70 per cent. or 80 per cent. muriate, potassium chloride, KCL. From this the equivalent percentage of actual potash, K_2O is obtained by multiplying by the factor .6319 and conversely. The factor for obtaining the per cent. of actual potash from sulfate of any grade is to multiply by .5408. An 80 per cent. muriate should therefore contain 50.56 per cent. actual potash and a 90 per cent. sulfate, only 48.67 actual potash.

MURIATE OF POTASH—POTASSIUM CHLORIDE.

Laboratory No.	742	906	2616	2763
	Per cent.	Per cent.	Per cent.	Per cent.
Potash, K_2O	47.45	54.73	44.64	49.53
Muriate, K C L	75.08	86.93	70.65	78.38

906—O. A. E. S., April 3, 1897 (L. M. Bloomfield).
2616—From Peter Conrad, Smithville, O., May 5, 1900 (J. W. Ames).
2763—O. A. E. S., March 27, 1901 (J. W. Ames).

BONE.

Laboratory No.	916	917	918	743	946	947	2711	Average raw bone.	Average steamed bone.
	Per cent.	Per cent	Per cent	Per ct.	Per ct.	Per ct.	Per ct.	Per cent.	Per cent.
Total phos. acid.	26.06	24.25	23.32	18.66	......	......	......	22 08	(26.06)
*Insol. " "	13.67	16.10	16.17	....	......	......	......	16.13	(13.67)
Available	12.39	8.15	7 56	....	......	......	......	7.85	(12.39)
Nitrogen	2.86	4.26	4.2	....	2.80	4.20	3.73	4.10	2.83
Nitrogen equiv. to ammonia	3.48	5.18	5.10	....	3.40	5.10	4.52	4.97	3.44

916—Steamed bone, Darling & Co., Chicago, Ill., 1897 (L. M. Bloomfield).

917—Ground raw bone, Darling & Co., Chicago, Ill., 1897 (L. M. Bloomfield).

918—Ground bone, 1897 (L. M. Bloomfield).

743—Raw bone, January 22, 1896 (L. M. Bloomfield).

946—Steamed bone, Official Association of Agricultural Chemists, 1897 (L. M. Bloomfield).

947—Raw bone, Official Association of Agricultural Chemists, 1897 (L. M. Bloomfield).

2711—Ground bone (raw), Official Association of Agricultural Chemists, 1900 (J. W. Ames).

*Insoluble in standard ammonium citrate solution. The same method was followed as with acid phosphates and mixed fertilizers; the results are to be taken as suggestive only since field tests show a higher proportion of available plant food.

*3 Ex. Sta. Bul. 127.

TANKAGE.

Laboratory No.	632	748	951	955	956	958	990
	Per ct.	Per ct.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent
Total phosphoric acid	5.83	3.60	9.35	10.08	17.88	17 58	17.13
Insoluble "	....	....	2.93	....	....	10.30	....
Available "	....	....	6.42	....	....	....	....
Nitrogen	6.58	8.61	5.04	4 82	5.18	4.94	5.31
" Equiv'l't to am'nia	7.99	10.52	6.12	5.78	6.29	6.07	6.44

632—9 and 15 tankage; September 17, 1894 (L. M. Bloomfield).

748—10 and 10 tankage; June 22, 1896 (L. M. Bloomfield).

951—7 and 30 tankage; Cleveland Dryer Co., September 4, 1897 (L. M. Bloomfield).

955—7 and 30 tankage; Cleveland Dryer Co , September 4, 1897 (L. M. Bloomfield).

956—7 and 30 tankage; September 4, 1897 (L. M. Bloomfield).

958—7 and 30 tankage; Cleveland Provision Co., September 21, 1897 (L. M. Bloomfield).

990—7 and 30 tankage; Cleveland Provision Co., April 5, 1898 (A. D. Selby).

TANKAGE.

Laboratory No.	1669	1672	1742	1743	1748	631	2227	2766
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Total phosphoric acid........ ..	14.56	14.98	5.64	12.91	11.76	7.02	16 95	14.35
Insoluble phosphoric acid ...	....	....	2 06	3.71	4.74	....	....	3.42
Available phosphoric acid.....	....	....	3.58	9.20	7.02	....	....	10[illegible]3
Nitrogen..........................	5.34	6.44	8.43	6.74	6.30	6 02	5.28	6[illegible]
" Equivalent to ammonia	6.48	7.68	10.18	8.11	8 39	7.31	6.41	7 80

1669—7 and 30 tankage; Milsom Rendering and Fertilizer Co., Buffalo, N. Y., September 15, 1898 (A. D. Selby).

1672—7 and 30 tankage; Cleveland Provision Co., October 20, 1898 (A. D. Selby).

1742—9½ and 20 tankage; Swift & Co., Chicago, Ill., June 5, 1899 (J. W. Ames).

1743—7 and 30 tankage; Cleveland Provision Co., June 5, 1899 (J. W. Ames).

1748—7 and 30 tankage; Cleveland Provision Co., June 5, 1899 (J. W. Ames).

2727—6½ and 40 tankage; Swift & Co. (ammoniated) bone, December 15, 1900 (J. W. Ames)

2766—7 and 30 tankage; Swift & Co., Chicago, Ill., April 1, 1901 (J. W. Ames)

ASHES.

CORN COB ASHES.

Laboratory No.	1772
	Per cent.
Insoluble matter	21.80
Phosphoric, acid P_2O_5	6.76
Potash, K_2O	35 50

From Geo. M. Layman, Piqua, O, July 8, 1899 (J. W. Ames).

HICKORY ASHES.

Laboratory No.	780
	Per cent.
Potash, K_2O	5.87

From Chas. H. Foote, Brooklyn, O, December 4, 1896 (L. M. Bloomfield).

COAL ASHES.

Laboratory No.	762
	Per cent.
Potash, K_2O	2 70
Soda, Na_2O	2 62

October 8, 1896 (L. M. Bloomfield).

ASH OF TORNILLO WOOD.*

Laboratory No.	941
	Per cent.
Soluble SiO_2	7.37
Insoluble SiO_2	14.70
Total SiO_2	22.07
Potash K_2O	11.35
Soda Na_2O	6.89
Calcium oxide CaO	32 46
Magnesium oxide MgO	8.12
Manganese oxide MgO	.48
Iron and Alumina Fe_2O_3 & Al_2O_3	.97
Chlorine Cl_2	.23
Sulfurtrioxide SO_3	.59
Phosphorus pentoxide P_2O_5	3.45

* From Official Association Agricultural Chemists, 1897 (L. M. Bloomfield).

MIXED FERTILIZERS.

Laboratory No.	966	993	1671	1744	1746	1747
	Per ct.	Per ct	Per ct.	Per ct.	Per ct.	Per ct.
Total phosphoric acid	13.09	....	14 60	12.88	9 68	13.86
Insoluble phosphoric acid	3.35	....	....	2.70	3.45	3.80
Water soluble phosphoric acid	7.72	....	....	7.52	4.46	5.53
Available phosphoric acid	9.74	11.52	12.28	10.18	6.22	10.06
Nitrogen	2.02	.95	1.40	1.95	4.10	1.55
Nitrogen equal to ammonia	2.46	1.15	1 70	2.25	4.98	1.90
Potash K_2O	....	3.40	2 34	5.02	4.90	1.60

166. Thos. E. Lockwood, December 11, 1897 (L. M. Bloomfield).

993. Bought by the Marlboro Home Mixing Association from Columbus Phosphate Co. (L. M. Bloomfield).

1671. Bought by the Marlboro Home Mixing Association from Columbus Phosphate Co. (A. D. Selby).

1744. Potato and general crop fertilizer, Cleveland Dryer Co., May 5, 1899 (J. W. Ames).

1746. Vegetable bone fertilizer, Milsom Rendering and Fertilizer Co., Buffalo, N Y., May 5, 1899 (J. W. Ames).

MIXED FERTILIZERS.

2722	901	902	903	957	1745	1959	2653	2654	1763	2715	2709	2712
Per ct.	Per ct.	Per ct.	Per ct.	Per ct	Per ct.	Per ct.	Per ct.	Per ct.	Per ct	Per ct	Per ct.	Per ct.
11.55	14.58	14.99	7.93	....	7.03	13.69	7.39	8.29	....	....	....	....
2.64	4.21	4.72	1.28	8.15	1.56	1.62	2.98	.64	....	....	....	....
.42	6.92	5.18	2.76	4.34	4.25	8.40	2.73	5.66	....	....	....	....
8.91	10.37	10.27	6.65	....	5.47	12.07	4.41	7.65	....	....	....	....
1.41	2.24	3.08	1.04	2.44	1.04	1.78	.79	.67	3.13	3.34	11.78	8.27
1.74	2.72	3.74	1.27	2.97	1.26	2.16	.96	.81	3.80	4.77	14.30	10.64
2.84	2.21	3.76	1.39	....	1.94	3.07	1.74	2.40	....	....	....	....

2722. Seneca Fertilizer Works, Tiffin, Ohio, December 15, 1900 (J. W. Ames).

901. Special phosphate, Scot Packing Co., Cincinnati, Ohio, (L. M. Bloomfield).

902. Potato and vegetable fertilizer, Cleveland Dryer Co., 1897 (L. M. Bloomfield).

903. Victor phosphate, Newburgh Fert. Co., Cleveland, O., 1897 (L. M. Bloomfield).

957. Home mixture No. 1, (L. M. Bloomfield).

1745. Erie King Fertilizer, Milson Rendering and Fert. Co. (J. W. Ames).

1959. From Home Mixing Association, per James O. Wilhelm, March 3, 1900 (J. W. Ames).

2653. "Good Investment" U. S. Fertilizer Co., Wheeling, W. Va., per C. C. Chapman, Massillon, Ohio, January 27, 1900 (J. W. Ames).

2654. Special Club Formula, U. S. Fertilizer Co., Wheeling, Va., per S. C. W ndle, Olivet, O., June 27, 1900 (J. W. Ames).

2715. Official Association Agr. Chemists, 1900 (J. W. Ames).

1763 Official Association Agr. Chemists, 1899 (J. W. Ames).

FERTILIZING CONSTITUENTS IN FEEDS.

In the analysis of such feeds as wheat bran, linseed meal, etc., a high nitrogen content is indicated by the high protein percentages. In a supplemental table to Bulletin 60 the ash content, nitrogen, phosphoric acid and potash percentages have been given in detail. The protein percentage in all the analyses under feeds, etc., is simply the nitrogen multiplied by 6.25; the per cent. of protein divided by this factor 6.25 will accordingly give that of the nitrogen. The following comparison of linseed meal, cotton seed meal and wheat bran in this regard may be of use:

COMPARISON OF FERTILIZING CONSTITUENTS OF LINSEED MEAL, COTTON SEED MEAL AND WHEAT BRAN.

Number.	Linseed meal.	Cotton seed meal.	Wheat bran.
	785	2714	Average 8 samples.
	Per cent.	Per cent.	Per cent.
Ash	4.98		5.97
Phosphoric acid P_2O_5	1.79	(2.68)	(2.89)
Potash K_2O	1.60	(1.79)	(1.61)
Nitrogen	5.50	7.35	2.50
Equivalent to ammonia	6.68	8.92	3.03

Figures in parenthesis ( ) are taken from table above mentioned, Bulletin 60.

ALBERT'S HORTICULTURAL MANURE.

Laboratory No.	739
	Per cent.
Water soluble phosphoric acid	9.83
Nitrogen	10.71
Nitrogen equivalent to ammonia	13.00
Potash K_2O	13.87

From T. Templin, Calla, O., Sept. 1, 1896 (L. M. Bloomfield).

JADOO FIBER—JADOO LIQUID.

Laboratory No.	963	964
	Per cent.	Per cent.
Total phosporic acid	0.90	0.0037
Insoluble phosphoric acid	0.17	....
Potash, K_2O	0.30	0.18
Nitrogen, N	0.64	0.06
Nitrogen, equivalent to ammonia, NH_3	0.78	0.065

963. December 2, 1897 (L. M. Bloomfield).
964. December 2, 1897 (L. M. Bloomfield).

LIQUID MANURE.

Laboratory No.	948
	Per cent.
Phosphoric acid	.004
Nitrogen	....
Nitrogen equivalent to ammonia	.61
Potash, K_2O	.49

948. From cistern at Dairy Barn, 1897 (L. M. Bloomfield).

V. LIMESTONES.

The following analyses of limestones have been made to develop the possible sources of a stone low in magnesia and thus adapted for use in beet sugar factories. All these except Nos. 973, 2720 and 2794 were originally published in Bulletin 99. The results of these two numbers are here published for the first time.

The stones herein mentioned will supply a list from which to choose one that might be applied upon soils relatively high in magnesia.

It may be remembered that outside our coal measure limes in Ohio and those from the limestones of which analyses are given, most of our native limes are high in magnesia, as for example sample No. 973, and therefore unsuited to application upon soils, if any, where the magnesia is thought to be excessive. These considerations have led to the collection of all these analyses in this form.

ANALYSES OF CLINTON LIMESTONE—QUARRY OF JOHN BROWN, REX, MIAMI COUNTY, OHIO [BROWN'S STATION].

Constituents determined.	1665. (1)	1666. (2)	1667. (3)	1668. (4)	1669. (5)	2794.
Water in air dry samples	0.06	0.06	0.06	0.06	0.06	....
Silica	0.65	0.57	0.44	4.25	0.50	.83
Iron oxide and alumina	0.82	0.61	0.54	3.67	0.70	1.38
Calcium carbonate	91.20	93.97	96.66	73.83	97.83	84.99
Magnesium carbonate	7.13	4 36	2.44	18.84	1.10	13.27
Totals	99.86	99.57	100.14	100.65	100.19	100.47

DESCRIPTION OF SAMPLES.

1665—Upper layer of shaly stone, about two feet of cover.

1666—About 18 inches below No. 1655. This stone and above is usually rejected in lime making.

1667—Body of massive stone, 5 to 6 feet thick, below 1666.

1668—Pocket of rotten stone in 1667.

1669—Special sample of massive stone, taken 1 foot above 1668, or rotten stone

Samples taken by A. D. Selby, July, 1898.

Analyses by R. E. Myers, at Ohio Experiment Station.

2794—Marble dust from Rex Marble Dust Co., Rex, O., 1900 (J. W. Ames).

ANALYSES OF UPPER HELDERBERG LIMESTONE FROM QUARRIES OF OHLEMACHER LIME CO. AND HARTSHORN QUARRY, MARBLEHEAD, OTTAWA COUNTY, OHIO, ALSO A CRUSHED STONE.

Constituents determined.	1676. (1)	1677. (2)	1678. (3)	1679. (H)	Crushed stone. 973.
Si ica	1.63	1.55	1.96	0 92	4.85
Iron oxide and alumina	0.15	.07	.20	0.21	2.95
Calcium carbonate	78.07	88.57	76.06	72.66	54.58
Magnesium carbonate	20.22	10.26	22.32	27.22	37.58
Totals	100.07	100.46	100.54	101.01	....

DESCRIPTION OF SAMPLES.

1676—Shaly stone, a few feet at top, west end of quarry.

1677—Best heavy (massive) stone, east end of quarry.

1678—Massive lower stone, below 1677 and separated by 2 to 3 feet of shaly stone.

1676-7-8—From Ohlemacher quarries.

1679—Hartshorn quarry—Upper 10 to 12 feet of shaly stone.

Sampled by A. D. Selby, 1898.

Analyzed by L. M. Bloomfield.

973—Crushed stone used on Springfield streets, 1898 (L. M. Bloomfield).

ANALYSES OF UPPER HELDERBERG LIMESTONE, MARION, OHIO, AND TRENTON MICH.

Constituents determined.	1680. (1)	1681. (2)	1682. (3)	1683. (1)	1684. (2)	2720
Silica	0.94	1.21	2.02	2.87	1.33	0.83
Iron oxide and alumina	0.14	0.39	0.20	0.34	.32	1.38
Calcium carbonate	92.32	73.16	60.02	64.25	63.20	84.99
Magnesium carbonate	7.98	26.34	37.72	32.67	35.61	13.27
Totals	101.38	101.10	99.96	100.13	100.46	100.47

DESCRIPTION OF SAMPLES.

From quarry of The John Evans Stone and Lime Co., Marion, O.
1680—Best and purest massive stone, 6 foot layer at east end of quarry.
1681—Upper 12 feet of 27 foot stone, below No. 1680, but at west end of quarry.
1682—Lower 12 feet of heavy stone, directly beneath No. 1681.
From quarries of Morris & Christian, Marion, O.
1683—Blue layer of stone in heavy, 27 foot layer.
1684—The 10 feet of massive stone above No. 1683.
Sampled by A. D. Selby, July, 1898.
Analyzed by L. M. Bloomfield.
2720—From Sibley Quarry Co., Trenton, Mich.
Sampled at works of Continental Sugar Co., Fremont O., 1900 (J. W. Ames).

VI. MINERAL WATERS.

Three analyses of mineral waters have been made in the laboratory of the Station for individuals who have kindly given consent to their publication. It will be clear to the reader that the analysis of mineral water involves large expense because of the great number of delicate determinations required. These analyses are published as matters of public information. The Station does not desire to undertake the analysis of such waters.

It is well known that such salts as sodium sulfate (Glauber salts) and magnesium sulfate (Epsom salts) are laxatives, and that waters containing them are aperient in character somewhat in proportion to the amounts of these constituents.

1. MINERAL WATERS: DEER LICK SPRING WATER, J. F. BRITTON, WEST SALEM, WAYNE CO., OHIO, 1896 (L. M. BLOOMFIELD).

Laboratory No. 752.	Grams per liter.	Grains per U. S. gallon.
Silica SiO_2	.0161	.939
Iron and alumina, Fe_2, O_3, Al_2 O_3	.0024	.139
Potash, K_2 O	.0069	.401
Soda, Na_2 O	.1963	11.419
Lime, CaO	.2829	16.460
Magnesia, MgO	.1418	8.248
Hydrochloric acid HCl	.0118	.686
Sulfuric acid	.5644	32.824
Carbonic acid	1.2027	11.788
Less O equivalent of chlorin	.0027	.156
Total solids	1.4226	82.748

CALCULATED AS SALTS.

Laboratory No. 752.	Grams per liter.	Grains per U. S. gallon.
Silica Sio_2	.0161	.939
Iron oxide and alumina, Fe_2 O_3 and Al_2 O_3	.0024	.139
Potassium chloride, KCl	.0109	.630
Sodium chloride, NaCl	.0108	.620
Sodium snlfate, Na_2 SO_4	.4362	25.370
Magnesium sulfate, Mg SO_4	.4251	24.720
Calcium carbonate, Ca CO_3	.4608	26.800
Calcium sulfate, Ca SO_4	.0603	3.500
Total solids	1.4226	82.748

2. MINERAL WATER FROM J. J. FORSYTHE, RARDEN, SCIOTO CO., OHIO, 1899 (J. W. AMES).

Laboratory No. 1772.	Grams per liter.	Grains per U. S. gal.
Silica, SiO_2	.0126	.7348
Iron and alumina, Fe_2O_3 and Al_2O_3	.0021	.1225
Potash, K_2O	.0150	.8748
Soda, Na_2O	.2999	174.895
Lime, CaO	.0779	4.5429
Magnesia, MgO	.0413	2.4085
Hydrochloric acid	.2886	16.8306
Sulfuric acid, SO_3	.0393	2.2920
Carbonic acid, CO_2	.1258	7.3364
Less O equivalent Cl	.0650	3.7906
Total solids	.8376	48 84
Free carbonic acid	.1580	9.2142
Hydrogen sulfid	.0063	.3674

CALCULATED AS SALTS.

	Grams per liter.	Grains per U. S. gal.
Silica, SiO_2	.0126	.7348
Iron and alumina, Fe_2O_3 and Al_2O_3	.0021	.1225
Potassium chloride, KCl	.0239	1.3938
Sodium chloride, NaCl	.4568	26.6497
Sodium sulfate, Na_2SO_4	.0698	2.6943
Sodium carbonate, Na_2CO_3	.0462	4.0706
Calcium carbonate, $CaCO_3$	.1391	8.1221
Magnesium carbonate, $MgCO_3$	.0867	5.0562
Total solids	.8372	48.84

3. MINERAL WATER FROM SPRING ON FARM OF F. KRICHBAUM, ASHLAND, ASHLAND CO., OHIO, 1900 (J. W. AMES).

Laboratory No. 2655.	Grams per liter.	Grains per U. S. gal.
Silica, SiO_2	.0395	2.3035
Iron and alumina, Fe_2O_3 and Al_2O_3	.0060	.3499
Potash, K_2O	.0040	.2332
Soda, Na_2O	.2750	16.0374
Lime, CaO	.3089	18.0144
Magnesia, MgO	.0586	3.4174
Hydrochloric acid, HCl	.0052	.3032
Sulfuric acid, SO_3	.4189	24.4294
Carbonic acid, CO_2	.4694	27.3744
Totals	1.5855	92.4628

CALCULATED AS SALTS.

	Grams per liter.	Grains per U. S. gal.
Silica, SiO	.0395	2.3035
Iron oxide and alumina, Fe_2O_3 and Al_2O_3	.0060	.3449
Potassium chloride, KCl	.0064	.3732
Sodium chloride, NaCl	.0036	.2099
Sodium sulfate, Na_2SO_4	.6254	36.4720
Magnesium sulfate, $MgSO_4$	.0997	5.8143
Magnesium carbonate, $MgCO_3$	.0533	3.1083
Calcium carbonate, Ca Co_3	.5516	32.1682
Total mineral matter	1.3855	80.7993
Free carbonic acid	.1988	11.5936
Total	1.5843	92.3920

INDEX.

Ohio Agricultural Experiment Station.

BULLETIN 128

AND

TWENTIETH ANNUAL REPORT FOR 1900-1901.

WOOSTER, OHIO, JULY 1, 1901.

The Bulletins of this Station are sent free to all residents of the State who request them. Persons who desire their address changed should give both old and new address. All correspondence should be addressed to EXPERIMENT STATION, WOOSTER, OHIO.

NORWALK, O.:
THE LANING COMPANY
1901

Twentieth Annual Report

OF THE

Ohio Agricultural Experiment Station

For the Year Ending June 30, 1901.

Published by Order of the State Legislature.

NORWALK, O.:
THE LANING COMPANY
1902

ANNOUNCEMENT.

The Ohio Agricultural Experiment Station is organized under an act of the General Assembly of Ohio, passed April 17, 1882, and supplemented by an act of Congress approved March 2, 1887.

The Station is prepared to test new varieties of grains, fruits and garden vegetables; to examine seeds that are suspected of being unsound or adulterated; to identify and name grasses, weeds and other plants; to identify insects and suggest measures for the control of such as are injurious; to give advice concerning the prevention of the fungous diseases which affect vegetation, and to assist in the diagnosis and control of tuberculosis and other diseases of cattle.

The Station is not prepared to furnish analyses of chemical or commercial fertilizers, as in Ohio that work is performed under direction of the Secretary of the State Board of Agriculture, at Columbus; but the Station will at all times respond to requests for advice concerning the use of such fertilizers.

The Station is not prepared to examine foods and dairy products suspected of adulteration, as that work is in charge of the Ohio Dairy and Food Commissioner, whose office is at Columbus.

Any citizen of Ohio has the right to apply to the Station for any information it can give, and all such applications will receive prompt attention.

Visitors to the Station are always welcome.

Address all communications to

EXPERIMENT STATION,
Wooster, Ohio.

ORGANIZATION OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

BOARD OF CONTROL.

R. H. WARDER	North Bend
J. T. ROBINSON	Rockaway
HON. L. M. STRONG	Kenton
THE GOVERNOR OF THE STATE / THE DIRECTOR OF THE STATION	*Ex officio*

OFFICERS OF THE BOARD.

J. T. ROBINSON	President
R. H. WARDER	Secretary
PERCY A. HINMAN	Treasurer

STATION STAFF.

CHARLES E. THORNE	Wooster	Director
WILLIAM J. GREEN	"	Horticulturist and Vice-Director
J. FREMONT HICKMAN, M. A. S.	"	Agriculturist
FRANCIS M. WEBSTER, M. S.	"	Entomologist
AUGUSTINE D. SELBY, B. Sc.	"	Botanist and Chemist
PERCY A. HINMAN	"	Bursar
JOHN W. AMES, B. Sc.	"	Assistant Chemist
JOHN F. HICKS	"	Assistant Botanist
WILMON NEWELL, M. Sc.	"	Assistant Entomologist
J. C. BURNESON, V. S.	"	Veterinarian
CLARENCE W. WAID, B. Sc.	"	Assistant Horticulturist
WILLIAM HOLMES	"	Foreman of Farm
CHARLES A. PATTON	"	Ass't Foreman and Meteorologist
ANNIE B. AYRES	"	Mailing Clerk
CARY WELTY	"	Mechanic
EDWARD MOHN	Strongsville	Supt. Northeastern Sub-Station
LEWIS SCHULTZ	Swanton, R. D.	Supt. Northwestern Sub-Station

The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.

To His Excellency, GEORGE K. NASH, *Governor of Ohio :*

SIR : I have the honor to transmit herewith the twentieth annual report of the Ohio Agricultural Experiment Station, for the fiscal year ending June 30, 1901.

R. H. WARDER, Secretary.

REPORT OF THE TREASURER.

To HON. J. T. ROBINSON, *President of the Board of Control:*

SIR: I respectfully submit herewith the financial report of this Station for the fiscal year ending June 30, 1901:

In Statements A, B, C and D, respectively, will be found a record of the receipts and expenditures from the various funds; Statement A being a statement of account with the annual appropriation received from the U. S. Treasury, and a copy of the report made to the Governor of the State, the Secretary of Agriculture and the Secretary of the U. S. Treasury; Statement B being a statement of account with the State Treasury; and Statement C showing the receipts from farm produce and other sources and expenditures from this fund.

The three statements, A, B and C, are combined in Statement D, which shows the total income and expenditures for the fiscal year.

STATEMENT A.

THE OHIO AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATION, 1900-1901.

Dr.

To receipts from the Treasurer of the United States, as per appropriation for the fiscal year ending June 30, 1901, as per act of Congress approved March 2, 1887		$15,000 00

Cr.

By expenditures for—		
Salaries	$12,362 32	
Labor	1,126 93	
Publications	60 84	
Postage and stationery	132 37	
Heat, light, water and power	71 50	
Seeds, plants and sundry supplies	455 22	
Fertilizers	96 52	
Feeding stuffs	283 34	
Library	165 25	
Tools, implements and machinery	119 12	
Scientific apparatus	33 75	
Contingent expenses	10 00	
Building and repairs	82 84	
		$15,000 00

I, the undersigned, duly appointed Auditor of the Corporation, do hereby certify that I have examined the books and accounts of the Ohio Agricultural Experiment Station for the fiscal year ending June 30, 1901, that I have found the same well kept and classified as above and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000; for all of which proper vouchers are on file and have been by me examined and found correct.

And I further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

{ SEAL OF INSTITUTION. }

Signed,

J. T. ROBINSON,

Auditor of Board of Control.

Attest: CHAS. E. THORNE, *Custodian.*

I hereby certify that the foregoing statement of account to which this is attached, is a true copy from the books of account of the institution named

P. A. HINMAN,

Treasurer of Board of Control.

STATEMENT B.

Ohio Agricultural Experiment Station in Account With the State Treasury.

Date of appropriation.	Appropriation for—	Total amount to the Station's credit.	Total amount expended.	Balance in treasury June 30, 1901.
1901	Expenses of Board of Control	$700 00	....	$700 00
	Sub-stations for field experiments	2,000 00	$322 06	1,677 94
	Bulletin illustration	400 00	....	400 00
	Special work in entomology, botany, horticulture and chemistry	4,000 00	762 23	3,237 77
	General repairs, labor and suppplies	3,500 00	2,989 29	510 71
	Investigation of tuberculosis, and other diseases of cattle	3,000 00	....	3,000 00
	Totals for 1901	$13,600 00	$4,073 58	$9,526 42
	Balance of appropriations for 1900 brought forward July 1, 1900			
1900	Expenses of Board of Control	$282 16	$241 43	$40 73
	Sub-stations for field experiments	1,758 15	1,758 15	....
	Bulletin illustration	276 73	275 77	96
	Special work in entomology, botany horticulture and chemistry	2,868 79	2,868 79	....
	General repairs, labor and supplies	550 83	550 83	....
	Investigation of tuberculosis, and other diseases of cattle	3,000 00	1,364 01	1,635 99
	New construction	4,850 00	4,000 00	850 00
	Totals	$27,186 66	$15,132 56	$12,054 10

STATEMENT C.

Ohio Agricultural Experiment Station in Account with Produce Fund.

To Receipts.

June 30, 1901.			
From sales of agricultural produce	$1,359 46		
" dairy produce	735 58		
" live stock	1,775 79		
" horticultural produce	1,289 50		
" botanical produce	15 18		
Northeastern Sub-station produce	43 10		
Northwestern Sub-station produce	84 46		
Total produce		$5,303 07	
labor		107 50	
rents		716 50	
miscellaneous sales		653 08	
fees for testing dairy cattle (milk test)		197 64	
fees for chemical analysis		66 00	
Total receipts for the year			$7,043 79
To balance brought forward July 1, 1900			1,384 72
Total			$8,428 51

By Expenditures.

June 30, 1901.		
For salaries, special and temporary services	12 75	
labor	4,723 44	
postage and stationery	29 02	
freight and express	384 10	
heat, light, water and power	80 46	
chemical supplies	5 27	
seeds, plants and sundry supplies	376 36	
feeding stuffs	93 02	
library	16 55	
tools, implements and machinery	42 55	
furniture and fixtures	69 88	
live stock	22 80	
traveling expenses	36 75	
contingent expenses	76 00	
building, repairs and farm improvement	661 74	
miscellaneous	441 05	
Total expenditures for the year		$7,071 74
By balance carried forward		1,356 77
Total		$8,428 51

STATEMENT D.

Total Receipts and Expenditures of the Ohio Agricultural Experiment Station for the Year Ending June 30, 1901.

Total Receipts.

From U. S. Treasury	$15,000 00	
State appropriations	13,600 00	
miscellaneous receipts	7,043 79	
Total receipts for the year		$35,643 79
To balance brought forward July 1, 1900		14,971 38
Total		$50,615 17

Total Expenditures.

For salaries and wages: technical and office staff		$12,731 97	
special and temporary services		12 75	
foremen and skilled laborers	$3,778 32		
ordinary laborers	6,549 11		
Total labor		10,327 43	
publications		469 39	
postage and stationery		328 24	
freight and express		488 30	
heat, light, water and power		676 81	
chemical supplies		45 59	
seeds, plants and sundry supplies		1,472 81	
fertilizers		266 87	
feeding stuffs		1,097 33	
library		467 90	
tools, implements and machinery		267 38	
furniture and fixtures		159 62	
scientific apparatus		167 47	
live stock		679 85	
traveling expenses		1,017 11	
contingent expenses		342 45	
buildings, repairs and farm improvement		5,743 95	
miscellaneous		441 05	
Total expenditures for the year			$37,204 30
By balance carried forward			13,410 87
Total			$50,615 17

Respectfully submitted.

P. A. Hinman, *Treasurer.*

REPORT OF THE DIRECTOR.

HON. J. T. ROBINSON, *President of the Board of Control:*

SIR: I have the honor to submit herewith the twentieth annual report of the Ohio Agricultural Experiment Station, for the year ending June 30, 1901.

In the study of the problems relating to maintenance of fertility the work of the year has further confirmed the adaptability of the soil upon which the Station is now located to this fundamental work. At the same time evidence is constantly increasing that a larger number of soils must be placed under experiment if the Station is to accomplish its full mission to the farmers of the state. The fact that certain sections of the state regularly produce four to eight bushels of wheat per acre more than other sections is one demanding careful investigation.

Experiments in cattle feeding were repeated during the past winter and their results, together with those of previous work of the same character, are being compiled for publication. The immense amount of careful computation required to put this work into available form, and the lack of suitable clerical help, has caused the accumulation of a large amount of unpublished data, which we now hope soon to have in print.

The Station's variety tests of cereals, fruits, etc., have been continued on the plans adopted nine years ago, and each year's work more fully demonstrates the possibility of making this work, when conducted on scientific principles, of enormous practical value. Taking wheat again as an illustration, an increase of a bushel per acre means the addition of at least $2,000,000 annually to Ohio's wealth; but certain varieties in the Station's tests have given a 9-year average of several bushels per acre more than others in general cultivation. Here again, however, is shown the need of opportunity for conducting these tests over a wider range of soils and climate than is now possible.

No part of the Station's work has yielded results of greater immediate value than its study of the fungous diseases of plants. Its work on apple scab has enabled practical orchardists to bring back, in isolated instances, the certainty in apple production which prevailed in Ohio forty years ago. What these have done others may do. Similar work is being done for the grape grower, and there is abundant reason to expect that the principal fungous pests of the farm, orchard and garden may soon be brought under control.

The chemical department of the Station has been of direct service to the farmers of the state in showing the probabilities of success in the production of beet sugar in different sections of the state. This work has been carried on in co-operation with the United States Department of Agriculture on the one hand, and with farmers of the state on the other, and it now serves as a reliable guide in the exploitation of this industry.

The investigation of tuberculosis of cattle, ordered by the last General Assembly, has been limited to the testing with tuberculin of such cattle as have been offered for such test, the tuberculin for this purpose being furnished by the Bureau of Animal Industry, U. S. Department of Agriculture. This work has shown that the disease exists in many herds of cattle throughout the state, but that it has not yet become so prevalent but that it may be kept under control. Some of the infirmaries and children's homes of the state have submitted their herds to the test, and in a few instances the disease has been found to be present. It would seem to be a duty of the state to require all herds belonging to its benevolent institutions to be subjected annually to this test. The appearance of the disease in some of the large dairy herds supplying our cities with milk certainly justifies municipal inspection of the milk supply.

Enough is now known regarding this disease to prove that its establishment within a herd of cattle means inevitable financial loss. The disease may be so insidious in its onset as to be unsuspected for a long time, and years may elapse before any alarming symptoms are manifested, but eventually the deaths will become more and more frequent, while the less conspicuous losses from feeding animals of impaired vitality will often be greater than those from actual death. Aside from the possibility of communicating this dread disease to human victims, especially to infants, through the use of the milk of tuberculous cattle—and the last word is far from having been said on this point—the certainty that financial loss follows in its train should be sufficient inducement to every cattle owner to see that his herds are free from it. The state, in making the tuberculin test free of charge, is offering him the opportunity to accomplish this end with the smallest possible loss.

The infection of tuberculosis is probably not communicated by mere proximity, but is spread among cattle chiefly or altogether through the discharges from the mouth and nose or through the milk. Its existence on a farm is not, therefore, so serious a menace to the farms adjoining as would be that of pleuro-pneumonia, Texas fever, or similarly contagious diseases, and such legislation as may be undertaken concerning it should have for its object the restriction of the traffic in the meat or dairy products of diseased cattle, rather than an attempt at immediate stamping out of the disease.

The following publications have been issued by the Station during the year:

Bulletin 121, pp. 1–70: A condensed handbook of the diseases of cultivated plants in Ohio. By A. D. Selby.

Bulletin 122, pp. 71–84: Onion Smut—preliminary experiments. By A. D. Selby.

Bulletin 123, pp. 85–102: I. Grape rots in Ohio. II. Experiments in the prevention of grape rot. By A. D. Selby.

Bulletin 124, pp. 103–120: The maintenance of fertility: Field experiments with fertilizers on corn, oats, and wheat, 1899 and 1900. By C. E. Thorne.

Bulletin 125, pp. 121–132: The maintenance of fertility: Field experiments with fertilizers on potatoes, 1894 to 1900. By C. E. Thorne.

Bulletin 126, pp. 133–174: Sugar beet investigations in Ohio in 1900. By A. D. Selby and J. W. Ames.

Bulletin 127, pp. 175–218: Miscellaneous chemical analyses. By A. D. Selby, J. W. Ames and others.

Bulletin 128, pp. 219–231: Meteorological summary, by C. A. Patton; Press bulletins 112–124 and index. This bulletin is appended to the present report.

ACKNOWLEDGMENTS.

The following publications have been received during the year as donations to the Station's library, or in exchange for its bulletins:

BOOKS, PAMPHLETS AND SCIENTIFIC PERIODICALS.

Agricultural Experiment Stations: The bulletins of all the experiment stations of the United States are regularly received.

AFRICA: Cape of Good Hope Department of Agriculture: Bulletins on orchard work, dairy industry and liver disease among calves. Capetown.

AUSTRALIA: A report upon some factors relating to the cane sugar industry of Australia, by Dr. Walter Maxwell, to the Right Hon. Edmund Barton, Esq., Premier Commonwealth of Australia.

New South Wales Botanic Gardens and Domains, Sydney: J. H. Maiden, Director. Annual reports for 1899 and 1900, and miscellaneous publications.

BARBADOES: Barbadoes Botanic Station, John R. Bovel, Superintendent: West Indian Hurricanes.

CANADA: Dominion Experimental Farms, Prof. Wm. Saunders, Director, Ottawa: Annual report and bulletins for 1900.

Department of Agriculture, North-West Territories, G. H. Bulyea, Commissioner, Regina: Annual report for 1900.

Experimental Farm for North-West Territories, Angus Mackay, Superintendent, Indian Head: Annual report for 1900.

Ontario Department of Agriculture, Hon. John Dryden, Minister, Toronto: Annual report for 1900, 2 vols.: Also, separate reports of the Agricultural College and Experimental Farm; Experimental Union; Live Stock Associations; Registrar of Live Stock; Farmers' Institutes; Bee Keepers' Association; Poultry Association; Fruit Growers' Association; Fruit Experiment Station and bulletins of the Agricultural College and Bureau of Industries.

ENGLAND: Annual report to the secretary of the Board of Agriculture on the distribution of grants for agricultural education and research, for the year 1899-1900, by P. G. Gragie.

Aynsome Agricultural Station and Farm: Grange-over-Sands, Lancashire, Prospectus of farm and laboratory.

Journal of the Royal Horticultural Society for 1901, Parts 1 and 2. London, 117 Victoria St., Westminster St. S. W.

Durham College of Science, Newcastle-upon-Tyne: Report on experiments with crops and stock during the season of 1900, compiled by T. H. Middleton, MSc.

Garforth experiments (the) 1899: Published by the East and West Ridings Joint Agricultural Council and the Yorkshire College.

FRANCE: Agenda Agricole et Viticole: par V. Vermorel: Villefranche (Rhone).

Bibliographia Lactaria: Premier supplement (Annee 1900) a la bibliographie generale des travaux parus sur le lait et sur l'allaitement jusq' en, 1899, par Le Dr. Henri de Rothschild, Paris: Octave Doin, Editeur, 8 Place de l'Odeon.

Comite de viticulture, Le, de l'arrondissement de Cognac, par James Hennessy, Cognac, France.

Congres international de l'enseignement agricole, tenu à Paris, du 14 au 16 Juin, 1900. M. de Lagorsse, Secretaire general. Paris, Imprimerie Nationale.

Congres international des stations agronomiques, tenu à Paris, du 18 au 20 Juin, 1900, M. Louis Grandeau, Secretaire general, Paris, France. Paris, Imprimerie Nationale.

Ecole Nationale d'Agriculture de Montpellier. Les effets de la foudre et la gelivre, par M. M. L. Ravaz et A. Bonnet.

Trois Jours en Beaujolais: Excursions viticoles offert par la Station Viticole de Villefranche (Rhone). V. Vermorel.

GERMANY: Konigl. botanischen Gartens und Museums zu Berlin: Notizblatt, 1900.

Die Botanischen Institute die freien und Hansestadt Hamburg. Im Auftrage der Oberschubchörde. Von Dr. A. Voigt.

Botanisches Museum, Abtheilung für Pflanzenschutz, zu Hamburg. II, 1899-1900. Dr. C. Brick.

Jahres-Bericht der Agrikulturchemischen Versuchsstation in Kiel, für 1899 and 1900, von Geh-Reg-Rath Prof. Dr. A. Emmerling.

Bericht über die Thatigkeit der Agriculturchemischen Versuchs-und Samencontrolstation in Köslin, für das Jahr 1899. Dr. Baessler, Director.

Jahresbericht der Landwirthschaftl. Versuchsstation zu Marburg, über das Statsjahr 1900-01. Erstattet von deren Vorstcher Prof. Dr. Dietrich.

INDIA: Government of Mysore: Report of the Agricultural Chemist, for the year 1899-1900.

Northwestern Provinces and Oudh: Report on the progress and condition of the Government Botanical Gardens, Saharanpur and Arnigadh, for the year ending March 31, 1901.

HAWAII: Biennial report of the Minister of public instruction for 1898-99. Honolulu.

HOLLAND: Koninklijk Zoologisch-Botanisch Genootschap te's-Gravenhage Verslag van den toetstand over het jaar 1900.

JAMAICA: Bulletin of the Botanical Department, by William Fawcett, Director of Public Gardens and Plantations.

JAPAN: L'Institut Agronomique de Sapporo, Japan, 1900. (Abridged history and description, published for the Paris Exposition.)

JAVA: Verslag over 1900 van het Proefstation voor Suikerriet in West-Java "Kagok" te Pekalongan, S. C. van Musschenbroek, President. Also: Medeelingen, Nos. 43, 45, 46, 47, 50, 51 with colored plates.

MEXICO: Boletin de la Parasitologia Agricola, Tomo I. Redactado Por el Professor A. L. Herrera.

SCOTLAND: West of Scotland Agricultural College, Glasgow, R. Patrick Wright, Principal: First annual report on agricultural experiments, conducted in 1899.

SERVIA: "Javremorac," Jardin botanique du Royaume de Serbie a Belgrade, VIII Annee.

SOUTH AMERICA: Buenos Ayres: Annales del Museo Nacional de Buenos Aires, Segunda Serie, Tomos IV, V, VI. Also: Communicaciones del Museo Nacional de Buenos Aires, Tomo I: Prof. Dr. Carlos Berg, Actual Director.

SPAIN: Memorias de la Real Academia de Ciencias exactas, fiscas y naturales de Madrid, Tomo XIV, Estudios preliminares sobre de la fauna malacologica de las islas Filipinas. Joaquin Gonzales Hidalgo.

SWEDEN: Nyt Magazin for Naturvidenskaberne grundlagt af den physiographiske forening í Christiana. 1901.

UNITED STATES: American Museum of Natural History, Central Park, N. Y. City. Extracts from bulletin.

California State Board of Horticulture, B. M. Lelong, Secretary, 6th Annual report, for 1897-98.

California Viticultural Commission and California State Agricultural Society: Reports and Transactions, from Prof. Chas. H. Shinn, Berkeley.

Cheese Making: By Prof. John W. Decker, Ohio State University, Columbus, Ohio.

Clark County (Ohio) Horticultural Society, A. E. Humphreys, Secretary, Report for 1899.

Colorado College Studies: Volume IX, May 1891. Colorado Springs, Colo,

Columbus Horticultural Society, Homer C. Price and John F. Cunningham, Secretaries: Journal for 1898, 1899 and 1900.

Continental Dorset Club, J. E. Wing, Secretary, Mechanicsburg, Ohio: Record, Volume 1, 1900.

Elisha Mitchell Scientific Society, Chapel Hill, N. C.: Journal, Seventeenth year.

Florida Department of Agriculture, B. E. McLin, Commissioner, Tallahassee: Report, 1899-1900.

German Kali Works, New York City; Reports of experiments in the use of fertilizers.

Idaho State Engineer: Biennial report for 1899-1900. D. W. Ross, State Engineer.

Illinois Department of Agriculture, W. C. Garrard, Secretary, Springfield: Transactions for 1884 to 1899. 16 Vols.

Illinois Horticultural Society, L. R. Bryant, Secretary, Princeton: Transactions for 1899 and 1900.

Illinois Live Stock Commission; C. P. Johnson, Secretary, Chicago: Annual report for 1899.

Illinois State Food Commission, Alfred H. Jones, Secretary, Chicago: First annual report.

Indiana Academy of Science: Proceedings, 1899. Geo. W. Benton, Editor, Indianapolis.

Indiana Department of Geology and Natural Resources, W. S. Blatchley, State Geologist, Indianapolis: Annual Report for 1900.

Indiana Horticultural Society, James Troop, Secretary, Lafayette: Transactions for 1899.

Iowa Geological Survey, Samuel Calvin, State Geologist, Des Moines: Annual report for 1900.

Iowa State Horticultural Society, Wesley Greene, Secretary, Des Moines. Transactions for 1895 to 1899, inclusive, 5 volumes.

Iowa State University, Iowa City: Bulletins from the laboratories of natural history.

Kansas State Board of Agriculture, F. D. Coburn, Secretary, Topeka: 12th Annual report for 1900.

Los Angeles Public Library, Los Angeles, Cal.: Annual report for 1900.

Maine Board of Agriculture, B. Walker McKeen, Secretary, Augusta: Bulletin for 1900.

Maine Registration Report for 1898 and 1899, A. G. Young, M. D. Reg. Augusta.

Massachusetts Horticultural Society, James W. Stockwell, Secretary, Boston: Transactions for 1900.

Michigan State Horticultural Society, E. C. Reid, Secretary, Agricultural College: 28th and 29th Annual Reports for 1898 and 1899. 2 Vols.

Michigan Weather Service, C. F. Schneider, Director, Lansing: Annual report for 1897.

Minnesota State Horticultural Society, A. W. Latham, Secretary, Minneapolis: Trees, Fruits and Flowers of Minnesota, 1900.

Missouri State Horticultural Society, L. A. Goodman, Secretary, Kansas City: 39th, 41st, 42d and 43rd Annual Reports for 1896, 1898, 1899 and 1900. 4 Vols.

Montana State Board of Horticulture: First Biennial Report for 1899–1900.

New York Department of Agriculture, C. A. Wieting, Secretary, Albany: Sixth Annual Report for 1899. 3 Vols.

New York State Horticultural Society, W. C. Barry, President: Proceedings 44th and 45th Annual meetings, 1899 and 1900.

New York State Library, Melvil Dewey, Director, Albany: Annual Report, 1899.

New York State Museum, Albany: Annual Reports of Director, State Botanist, State Entomologist and State Geologist.

North Carolina Horticultural Society: Experiments with fertilizers at Southern Pines, N. C.

North Dakota Department of Agriculture and Labor, Henry U. Thomas, Commissioner, Fargo: Annual Report for 1900.

Ohio Archaeological and Historical Society, E. O. Randall, Secretary, Columbus: Quarterly Reports.

Ohio State Board of Agriculture, W. W. Miller, Secretary, Columbus: 54th Annual Report for 1899.

Ohio Statistics and other state publications, from Hon. L. C. Laylin, Secretary of State, Columbus.

Oregon Board of Horticulture, John Minto, Secretary, Salem: Annual Report for 1899–1900.

Peninsula Horticultural Society, Wesley Webb, Secretary, Dover, Del.: Transactions for 1901.

Ohio State Horticultural Society: Copies of annual reports to complete files, from B. H. Brown, Oxford; Chas. Lauppe, Urbana; G. Swably, Tiffin, and Samuel Taylor, Pleasant Corners.

Pennsylvania Department of Agriculture, Prof. John Hamilton, Secretary, Harrisburg: Reports for 1884 and 1886 to 1892, 1898 and 1900. 9 vols. Also bulletins to 1898.

Rhode Island State Board of Agriculture, Geo. A. Stockwell, Secretary, Providence: Annual Report for 1899.

St. Louis Academy of Science: Transactions for 1900.

Trumbull County, (Ohio) Horticultural Society, E. W. Turner, Secretary: Proceedings for 1881, 1882 and 1883.

University of the State of New York, Albany: Bulletins of the New York State Museum, Frederick J. Merrill, Director: Home Education Bulletin No. 31, on Public Libraries and Popular Education.

U. S. Bureau of Statistics, Treasury Department, O. R. Austin, Chief, Washington, D. C.: Monthly summary of finance and commerce and annual reports of commerce and navigation of the United States.

U. S. Department of State: Commercial relations, 1899: Consular reports: Special reports on Tariffs of Foreign Countries.

U. S. Geological Survey, Nineteenth Annual report, from Hon. Marcus Hanna, U. S. Senate.

West Virginia Board of Agriculture, J. B. Garvin, Secretary 5th Biennial report for 1899-1900.

Wisconsin Academy of Science, Arts and Letters, F. C. Sharp, Secretary: Transactions for 1899, 1900-1901.

Wisconsin Horticultural Society, F.W. Case, Secretary: Transactions for 1891-1892.

GOVERNMENT SERIAL PUBLICATIONS.

Agricultural Gazette of New South Wales: Issued monthly by direction of the Secretary for Mines and Agriculture, Sydney, New South Wales, Australia.

Agricultural Journal, Cape of Good Hope: Published monthly by the Department of Agriculture, Cape Town, South Africa.

Agricultural Journal and Mining Record: Issued fortnightly by the Natal Department of Agriculture and Mines, Maritzburg, Natal, South Africa.

Annuaire Agricole de la Suisse: Publie par le Departement federal de l' Agriculture (Berne, Switzerland).

Boletin de Agricultura, Mineria e Industrias: Publicado por la Secretaria di Fomento, Colonizacion e Industria de la Republica Mexicana: (Published monthly, City of Mexico.)

Boletin de la Sociedad Nacional de Agricultura: (Published monthly at 772 Monjitas, Chile, South America.)

Boletin Mensual de Observatorio Meteorologico Central de Mexico: Oficina Tipografica de la Secretaria de Fomento, (City of Mexico.)

Boletin de la Sociedad Agricole Mexicana, Imp. de la Secretaria de Fomento. (City of Mexico.)

Boletin de Agricultura. Secretaria de Agricultura Commercio e obras Publicas do estado de Sao Paulo. (Sao Paulo, Brazil.)

Chronique Agricole du Canton de Vaud. Organe de l' Institute Agricole de Lausanne. Publie sous les auspices du Departement de l'Agriculture. (Lausanne, Switzerland.)

Consular Reports: Published monthly by the U. S. Department of State, Washington, D. C.

Experiment Station Record: Published monthly by Office of Experiment Stations, U. S. Department of Agriculture, Washington, D. C.

Journal of Agriculture and Industry of South Australia: Issued monthly under direction of the Hon. Ministers of Agriculture and Industry, Adelaide, South Australia.

Queensland Agricultural Journal: Issued by direction of the Secretary of Agriculture, Brisbane, Queensland, Australia.

U. S. Monthly Weather Review: Prepared under the direction of the Chief of the U. S. Weather Bureau, Washington, D. C.

AGRICULTURAL AND TRADE JOURNALS.

Acker und Gartenbau Zeitung, Milwaukee, Wis.
Agricultural Epitomist, Indianapolis, Ind.
Agricultural Student, Columbus, Ohio.
American Agriculturist, New York City.
American Farmer, Indianapolis, Ind.
American Grange Bulletin, Cincinnati, Ohio.
American Guernsey Cattle Club Herd Register, Petersboro, N. H.
American Sheep Breeder and Woolgrower, Chicago, Ill.
Beet Sugar Gazette, Chicago, Ill.
Boletin de Agricultura Tropical. San Jose de Costa Rica, C. A.
Breeder and Farmer, Zanesville, Ohio.
Breeder's Gazette, Chicago, Ill.
California Cultivator, Los Angeles, Cal.
Canadian Entomologist, London, Ontario, Canada.
Chicago Daily Drovers' Journal, Chicago, Ill.
Cincinnati Price Current, Cincinnati, Ohio.
Daily Drovers' Telegram, Kansas City, Mo.
Dairy and Creamery, Chicago, Ill.
Deutsch-Amerikanischer Farmer, Lincoln, Chicago and New York.
Deutsche Landwirtschaftliche Wochenschrift, Berlin, Germany.
Dorset Quarterly, Washington Pa.
Fanciers' Review and Fruit Grower, Chatham, N. Y.
Farm and Fireside, Springfield, Ohio.
Farm Home, The, Springfield, Ill.
Farmers' Advocate, London and Winnipeg, Canada.
Farmers' Guide, Huntington, Ind.
Farmers' Home, Dayton, Ohio.
Farmers' Institute Bulletin, Fayetteville, N. Y.
Farmers' Review, Chicago, Ill.
Farmers' Tribune, Des Moines, Iowa.
Farmers' Voice, Chicago, Ill.
Farm, Field and Fireside, Chicago, Ill.
Farm Journal, Philadelphia, Pa.
Farm, Stock and Home, Minneapolis, Minn.
Fruit Growers' Journal, Cobden, Ill.
Fruit World, Los Angeles and San Francisco, Cal.
Gleanings in Bee Culture, Medina, Ohio.
Golden Egg, The, St. Louis, Mo.
Green's Fruit Grower, Rochester, N. Y.
Grele, La, Station Viticole, Villefranche, (Rhone) France.
Hoard's Dairyman, Fort Atkinson, Wis.
Holstein Friesian Register, Brattleboro, Vt.
Homestead, The, Des Moines, Iowa.
Hospodar (Bohemian), Omaha, Neb.
Indiana Farmer, Indianapolis, Ind.
Insect World (Japanese), Gifu, Japan.
Japanese Agriculturist (Japanese), Azabu, Tokio, Japan.
Jersey Bulletin, Indianapolis, Ind.

Journal of Agriculture, St. Louis, Mo.
La Laiterie Belge, Enghein, Belgium.
Live Stock Journal, Chicago, Ill.
Michigan Sugar Beet, Bay City, Mich.
Mirror and Farmer, Manchester, N. H.
Montana Fruit Grower, Missoula, Mont.
National Farmer and Stock Grower, National Stock Yards, Chicago, Ill.
National Fruit Grower, St. Joseph, Mich.
National Provisioner, New York, N. Y.
National Stockman and Farmer, Pittsburgh, Pa.
Naturaliste Canadian, Le, Chicoutimi, Quebec, Can.
North American Horticulturist, Monroe, Mich.
Northwest Horticulturist, Tacoma and Seattle, Wash.
Ohio Farmer, Cleveland, Ohio.
Oregon Agriculturist, Portland, Oregon.
Popular Agriculturist (Japanese), Tokyo, Japan.
Practical Dairyman, Chatham, N. Y.
Practical Farmer, Philadelphia, Pa.
Prairie Farmer, Chicago, Ill.
Revue des Cultures Coloniales, Paris, France.
Southern Planter, Richmond, Va.
Southern Farm Magazine, Baltimore, Md.
Statistical Sugar Trade Journal: Willett & Gray, 91 Wall St., N. Y. City.
Strawberry Specialist, Kittrell, N. C.
Sugar Beet, Philadelphia, Pa.
Tri-State Farmer and Gardener, Chattanooga, Tenn.
Wallace's Farmer, Des Moines, Iowa.
West Virginia Farm Reporter, Charleston, W. Va.
Western Creamery, San Francisco, Cal.
Western Fruit Grower, St. Joseph, Mo.
Western Tobacco Journal, Cincinnati, Ohio.

GENERAL NEWSPAPERS.

From Ohio.

Barberton Leader, Barberton.
Cumberland Echo, Cumberland.
De Graff Journal, De Graff.
Fremont Journal, Fremont.
Geneva Free Press, Geneva.
Geneva Times, Geneva.
Greenville Democrat, Greenville.
Hardin County Republican, Kenton.
Jacksonian, Wooster.
Monroe Journal (German), Woodsfield.
New Waterford Magnet, New Waterford.
News Democrat, Georgetown.
Ohio State Journal, Columbus.
Press-Review, Payne.
Reveille Echo, East Palestine.
Saturday Whetstone, Barnesville.
Semi-Weekly Gazette, Delaware.
Shelby Times, Shelby.
Sugar Creek Budget, Sugarcreek.

Tiffin Weekly News, Tiffin.
Tipp Herald, Tippecanoe City.
Tuscarawas Chronicle, Uhrichsville and Dennison.
Wayne County Herald, Wooster.
Weekly Gazette, Cincinnati.

From Other States.

Baltimore Weekly Sun, Baltimore, Md.
Detroit Free Press, (Semi-weekly), Detroit, Mich.
Kansas Semi-Weekly Capital, Topeka, Kan.
Orilla Packet, Orilla, Ontario, Canada.
Public Ledger (Daily), Philadephia, Pa.
Rural Topics, Morgan City, La.
Salt Lake Herald (Semi-weekly), Salt Lake City, Utah.
Weekly Union, Manchester, N. H.

The station is also under obligations for the following favors:

SEEDS, PLANTS AND SUNDRIES.

Albright, B. F., Coalburg, O.; one variety of potato.
Boyle, James, Salem, O.; one "Taylor Steel Stanchion."
Bucher & Gibbs Plow Co., Canton, O.; one Bucher & Gibbs plow.
Crawford, M., Cuyahoga Falls, O.; one variety of grape.
Doughton, H. W., Moorestown, N. J.; one gallon of "Fly Killer" oil.
Earhart, W. H., Lexington, O; apple cions.
German Kali Works, 93-99 Nassau St., New York City; samples of potash salts for fertilizer experiments.
Hale, J. H., South Glastonbury, Conn.; one variety of strawberry.
Hallock Weeder Co., York, Pa.; one Hallock Weeder.
Henderson & Co., Peter, New York City; seventy-five varieties of seeds.
Leggett Bros., New York City; one spray pump.
Mace, George W., Greenville, O.; four quarts of seed corn.
Miller, E. J., Millersburg, O.; four varieties of potatoes, one variety of strawberry.
Minor & Co., W. E., Cleveland, O.; five gallons of "Minor's Fluid."
McCormick, C. H., McCormick, O.; four quarts of seed corn.
Nichols, A. M., Granville, O.; one variety of tomato seed,
Orr & Cooper, Pittsburg, Pa.; three gallons of "Fly Killer."
Reid, James L., Delavan, Ill.; four quarts of seed corn.
Ripley Hardware Co., Grafton, Ill.; two gallons Ripley Fly Killer.
Sampsel, S. A., Clyde, O.; one variety of strawberry.
Sprague Commission Co., Chicago, Ill.; three gallons of "Fly Bouncer."
Seneca White Lime Co., Fostoria, O.; five barrels of ground lime.
Skillman, B. H., North Middletown, Ky.; two bushels blue grass seed in the chaff.
Teeter. D. M., Bellville, O.; one variety of strawberry.
Warren, John, Kingston, O.; one peck of Blue Ridge wheat.

Respectfully submitted,

CHAS. E. THORNE, Director.

APPENDIX.

BULLETINS

OF THE

Ohio Agricultural Experiment Station.

1900—1901.

CONTENTS.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 128. JUNE, 1901.

METEOROLOGICAL SUMMARY—PRESS BULLETINS—INDEX.

METEOROLOGICAL SUMMARY FOR 1900.

BY C. A. PATTON.

EXPLANATION OF TABLES.

The following tables contain statistics of temperature, rainfall, etc., for the year, and are compiled from data obtained by daily observations. T stands for "trace;"— less than .01 inch of rainfall. Temperature is given in degrees Fahrenheit.

Table I shows the daily rainfall at the Station during the year in inches and hundredths.

Table II shows the daily mean temperature for each day of 1900 and the monthly mean temperature with thirteen years' average.

Table III gives a comparison of the monthly mean temperature and rainfall for the Station, with thirteen years' average for the same.

Table IV gives a comparison of the monthly mean temperature and rainfall for the state, with thirteen years' average for the same.

Table V gives the monthly mean temperature and rainfall for the Station and State for 1900 with thirteen years' average for the same.

Table VI contains the mean temperature, the highest and lowest temperatures, with the range of temperature for each month; the number of clear, fair and cloudy days; the rainfall, snowfall and prevailing direction of wind, for the Experiment Station 1900.

Table VII contains the principal points of interest on temperature, state of weather and raintall for the Station during the year and a grand summary for thirteen years.

Table VIII contains the principal points of interest on temperature, state of weather and rainfall for the State during the year and a grand summary for eighteen years.

The statistics for the State, and for this Station previous to 1893, are compiled from the publications of the Ohio Meteorological Bureau and State Weather Service, the thirteen years' average being computed from the observations of the Wooster Station of the Ohio Meteorological Bureau, now located on the grounds of the Experiment Station, one mile south of Wooster.

NOTES ON THE WEATHER AT THE STATION, 1900—SUMMARY BY MONTHS.

JANUARY.

The mean temperature for January was 30.2°, which is 2.9° above the Station average for January. The highest temperature, 54°, occurred on the 24th; the lowest,—5°, on the 31st. Cloudy weather prevailed. Rain or snow fell on seventeen days. The total precipitation was 2.78 inches, which is .51 inch below the Station average for January. The prevailing wind was southwest.

FEBRUARY.

The mean temperature for February was 25°, which is 2.7° below the Station average for February. The highest temperature, 65°, occurred on the 8th; the lowest,—10°, on the 27th. Cloudy weather prevailed. Rain or snow fell on fourteen days. The total precipitation was 2.74 inches, which is .40 inch below the Station average for February. The prevailing wind was west.

MARCH.

The mean temperature for March was 31.8°, which is 3.5° below the Station average for March. The highest temperature, 57°, occurred on the 6th; the lowest,—4°, on the 17th. Cloudy weather prevailed. Rain or snow fell on thirteen days. The total precipitation was 2.25 inches, which is 1.00 inch below the Station average for March. The prevailing wind was north northwest.

APRIL.

The mean temperature for April was 47.8°, which is 1° below the Station average for April. The highest temperature, 78°, occurred on the 29th; the lowest, 20°, on the 10th. Clear weather prevailed. Rain fell on six days. The total precipitation was 1.70 inch, which is .76 inch below the Station average for April. The prevailing wind was north.

MAY.

The mean temperature for May was 61.5°, which is 3.6° above the Station average for May. The highest temperature, 89°, occurred on the 16th; the lowest, 25°, on the 15th. Clear weather prevailed. Rain fell on eight days. The total precipitation was 2.23 inches, which is 1.96 inch below the Station average for May. The prevailing wind was northeast.

JUNE.

The mean temperature for June was 68.5°, which is .4° above the Station average for June. The highest temperature, 90°, occurred on 24th; the lowest, 44°, on the 4th. Fair weather prevailed. Rain fell on eleven days. The total rainfall was 3.71 inches, which is .29 inch below the Station average for June. The prevailing wind was north.

JULY.

The mean temperature for July was 72.6°, which is 1.7° above the Station average for July. The highest temperature, 95°, occurred on the 4th; the lowest, 44°, on the 1st. Clear weather prevailed. Rain fell on thirteen days. The total precipitation was 5.65 inches, which is 1.36 inch above the Station average for July. The prevailing wind was north and southwest.

AUGUST.

The mean temperature for August was 74°, which is 4.8° above the Station average for August. The highest temperature, 94°, occurred on the 7th; the lowest, 49°, on the 4th. Clear weather prevailed. Rain fell on twelve days. The total rainfall was 5.97 inches, which is 3.05 inches above the Station average for August. The prevailing wind was southwest.

SEPTEMBER.

The mean temperature for September was 67.1°, which is 3.7° above the Station average for September. The highest temperature, 89°, occurred on the 1st, 11th and 26th; the lowest, 41°, on the 19th. Clear weather prevailed. Rain fell on eight days. The total rainfall was 2.19 inches, which is .92 inch below the Station average for September. The prevailing wind was southwest.

OCTOBER.

The mean temperature for October was 58.9°, which is 8.5° above the Station average for October. The highest temperature, 86°, occurred on the 6th; the lowest, 30°, on the 18th. Clear weather prevailed. Rain fell on four days. The total rainfall was 2.10 inches, which is .42 inch below the Station average for October. The prevailing wind was south.

NOVEMBER.

The mean temperature for November was 40.6°, which is .7° above the Station average for November. The highest temperature, 69° occurred on the 1st; the lowest, 6°, on the 16th. Cloudy weather prevailed. Rain or snow fell on fourteen days. The total precipitation was 4.30 inches, which is .80 inch above the Station average for November. The prevailing wind was southwest.

DECEMBER.

The mean temperature for December was 30.7°, which is 1° below the Station average for December. The highest temperature, 55°, occurred on the 23rd; the lowest, 11°, on the 15th. Cloudy weather prevailed. Rain or snow fell on twelve days. The total precipitation was .99 inch, which is 1.38 inch below the Station average for December. The prevailing wind was southwest.

METEOROLOGY—TABLE I—RAINFALL.

DAILY RAINFALL AND MELTED SNOW FOR 1900 AT EXPERIMENT STATION.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	.10	.05	.50			.31		.15			.13	
2	T	.05		.15		.05						
3		.05		T	T		T		.15			.02
4		.13	.20	T	T		.09		.04			.26
5	.60		.13				T					.06
6			.55			.78			.06	T		
7	.02					.46	T		.57	.60	T	.09
8		.68			.27	.17	.72			.13	.06	
9		.08			.10		.62		.51		.04	.01
10	.04		T									
11	1.01		.02	.42	T		.22				.04	T
12	.09	.30		T	T		.82	.15				T
13	.02	.45		T		T		.11			T	.03
14	.02	T	T			1.49					.01	T
15		T	.02					1.30			.10	T
16	.20	T	.10	.03			.16	.46		T		T
17		.05		.50			.85		T		.70	.02
18	.02		T	T	T		.40					.05
19	.02		.20		.24		1.06				.31	
20	.33		.02					1.00	.20		.40	
21		.30		.48		.06		.68			.28	
22		.10		.12		.03				.01	T	
23		.05					T	.02		1.36	.37	.03
24		.20				T	.18	.90			.68	
25	.05		.06			.06	.98	.06	T		.52	.02
26	T		.25			.28					.66	
27	T		T		.48			.81	T			.10
28	.05	.25			.16				.02		T	.30
29	.05		.10		.02	.02	.10	.33	.64		T	
30	.08		.10		.10		.05			T		T
31	.08				.86							T
Totals	2.78	2.74	2.25	1.70	2.23	3.71	5.65	5.97	2.19	2.10	4.30	.99
Averages	.09	.10	.07	.06	.07	.12	.18	.19	.07	.07	.14	.03

METEROLOGY—TABLE II—TEMPERATURE.

MEAN TEMPERATURE AT THE STATION FOR EACH DAY OF 1900.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	9.0	2.0	30.5	40.0	53.0	70.0	61.0	66.0	73.0	59.0	58.5	36.0
2	16.5	11.0	25.0	41.5	61.5	72.5	69.0	65.0	74.0	70.5	45.0	39.0
3	21.0	21.0	28.0	43.0	53.5	58.0	80.5	68.5	73.0	71.0	43.5	40.0
4	24.0	34.5	35.0	35.0	43.0	57.0	82.0	66.0	68.5	70.5	45.5	39.0
5	34.0	25.5	28.5	41.5	43.0	64.0	83.5	74.5	68.5	73.0	48.0	35.0
6	37.5	31.5	43.0	51.0	52.5	70.0	82.5	80.5	76.5	73.0	40.5	34.0
7	41.5	43.0	34.5	60.0	61.5	72.5	83.0	80.0	73.5	65.5	40.0	35.5
8	37.5	57.5	33.5	31.0	71.5	72.0	72.0	78.0	71.5	54.5	33.0	38.0
9	33.5	38.0	40.5	33.0	51.0	59.5	63.5	77.0	75.0	50.0	31.5	26.5
10	36.0	29.0	40.5	30.5	45.0	65.5	65.5	78.0	74.5	48.5	31.5	21.0
11	38.5	32.5	30.0	31.5	61.0	72.5	76.5	80.0	77.0	49.5	36.0	22.5
12	31.5	39.0	24.5	37.0	67.0	63.5	65.5	79.0	71.5	54.5	33.0	22.0
13	31.5	37.5	36.5	34.0	71.0	73.0	65.5	74.5	64.0	56.5	40.0	32.0
14	37.5	24.5	28.5	39.0	74.5	71.0	69.0	74.5	63.5	57.0	27.0	21.0
15	40.5	24.0	22.5	46.5	75.0	65.0	77.5	61.0	66.5	55.0	23.0	16.5
16	39.5	16.5	15.5	56.5	71.5	63.0	79.0	72.0	63.5	53.5	20.5	21.5
17	36.0	11.0	6.0	57.0	73.0	65.0	80.5	74.0	53.0	46.5	31.0	23.5
18	48.0	7.5	29.5	64.0	61.5	65.0	74.5	76.0	56.5	48.5	51.5	35.5
19	46.5	16.5	41.5	56.5	57.5	61.5	75.0	77.0	58.5	49.5	60.0	36.0
20	40.0	20.5	30.5	51.5	52.0	64.5	74.5	77.5	64.0	49.5	60.0	28.0
21	34.0	37.0	28.0	57.0	54.0	68.0	71.0	74.5	66.0	59.5	50.0	29.0
22	38.5	32.5	36.5	62.0	58.5	71.0	71.5	71.0	55.0	66.0	50.5	42.0
23	41.0	33.0	42.5	56.5	64.5	72.5	77.0	73.0	61.5	67.0	50.5	47.0
24	40.0	17.5	30.5	55.5	65.5	75.0	74.	75.5	62.0	56.5	46.0	41.0
25	37.0	12.0	35.0	52.0	65.5	75.5	70.5	77.0	74.0	59.5	38.5	29.5
26	17.5	11.0	42.0	52.5	64.0	77.0	65.5	76.5	76.5	64.5	35.5	24.5
27	18.0	9.5	37.0	47.5	65.5	76.0	62.0	75.5	69.0	57.5	35.5	31.0
28	18.0	24.0	32.5	52.0	61.0	79.5	67.0	73.5	62.5	50.5	38.0	28.5
29	4.0	....	30.5	58.0	65.0	73.5	73.5	78.5	63.5	59.5	35.0	23.0
30	15.0	....	31.5	57.0	72.5	62.0	72.0	71.5	57.5	62.5	33.0	22.0
31	3.0	....	34.5	....	68.5	....	69.0	69.5	....	66.0	....	33.0
Monthly mean	30.2	25.0	31.8	47.8	61.5	68.5	72.6	74.0	67.1	58.9	40.6	30.7
Thirteen-year av'age	27.8	27.7	35.8	48.8	57.9	68.1	70.9	69.2	63.4	50.4	39.9	31.7

METEOROLOGY—TABLE III.

MONTHLY MEAN TEMPERATURE AND RAINFALL FOR THIRTEEN YEARS AT WOOSTER.

Temperature in degrees Fahrenheit.

	January.	February.	March.	April.	May	June.	July.	August.	September.	October.	November.	December.	Year.
1888	23.0	28.4	31.7	46.3	57.7	68.9	70.1	67.8	57.1	44.9	40.7	31.4	47.3
1889	31.1	22.9	38.7	47.1	57.8	64 5	70.0	66.0	60.8	45.3	39.3	40.7	48.6
1890	36.0	36.6	30.9	48 4	56.0	69.8	70.5	65.8	59.6	50.0	41.3	28.8	49.5
1891	30.0	34.0	32.0	49.0	52.0	68.0	68.0	71.0	68.0	49.0	38.0	37.0	49 6
1892	22.0	33.0	33.0	47.0	57.0	70.0	70.0	69.0	61.0	49.0	38.0	25.0	48.0
1893	18.0	28.0	38.0	50.1	57.6	69.3	72.0	67.9	63.2	52.3	37.7	30 9	48.7
1894	32.8	26.7	43.5	50.5	57.5	67.9	71.4	69.2	66.1	52.3	36.5	32.9	50.6
1895	21.9	17.9	32.4	49.5	59.4	69.9	68.6	70.9	66.5	44.2	40.4	32.8	47.8
1896	27.9	29.2	29.8	51.6	64.5	65.6	70.2	68.5	60.6	45.8	44.4	30.6	49.3
1897	24.0	30.0	39.3	47.2	53.4	64.3	73.2	67.0	66.7	55.9	40.7	31.8	49.4
1898	31.6	27.4	43.3	45.3	58.2	68.7	74.5	71.1	66.2	52.6	38.4	27.9	50.4
1899	26.6	21.8	35.0	52.1	60.0	69.4	70.0	71.0	61.6	55.0	43.2	29.0	49.5
1900	30.2	25.0	31.8	47.8	61.5	68.5	72.6	74.0	67.1	58.9	40.6	30.7	50.7
Averages	27.3	27.7	35.3	48.8	57.9	68.1	70.9	69.2	63.4	50.4	39.9	31.7	49.1

Rainfall—Inches.

1888	3.52	2.43	3.34	2.48	3.82	2.31	4.54	4.35	1.92	3.18	4.95	1.39	3.18
1889	4.83	2.42	2.13	1.58	2.97	4.86	6.73	1.98	4.05	1.36	3.53	3.98	3.32
1890	4.71	6.20	4.37	3.10	6.01	5.57	2.67	4.66	5.12	7.45	2.61	1.74	4.51
1891	2.74	4.83	3.71	1.66	2.24	7.13	3.28	1.85	0.94	1.33	5.73	2.92	3.20
1892	2.67	2.67	3.38	2.44	7.69	7.89	4.73	2.69	3.20	0.37	2.06	1.74	3.46
1893	4.01	6.33	1.89	5.66	6.28	2.51	1.38	1.53	1.85	5.18	2.49	1.50	3.38
1894	2.19	3.37	2.36	1.74	4.41	2.23	1.38	0.76	4.07	2.53	2.41	3.15	2.55
1895	3.92	1.00	1.98	1.69	1.38	4.20	2.19	2.30	3.92	1.15	4.21	3.51	2.62
1896	1.73	2.27	3.67	3.34	3.41	3.98	8.05	1.96	5.16	0.71	1.78	2.41	3.21
1897	2.82	2.64	2.81	2.75	4.97	2.98	3.89	3.86	0.29	0.89	5.76	2.50	3.01
1898	4.10	2.27	6.44	2.56	4.60	2.70	6.79	5.53	2.15	4.28	4.14	2.29	3.99
1899	3.29	1.64	3.95	1.28	4.42	1.95	3.73	0.53	5.56	2.21	1.59	2.78	2.74
1900	2.78	2.74	2.25	1.70	2.23	3.71	5.65	5.97	2.19	2.10	4.30	.99	3.05
Averages	3.29	3.14	3.25	2.46	4.19	4.00	4.29	2.92	3.11	2.52	3.50	2.37	3.25

METEOROLOGY—TABLE IV.

MONTHLY MEAN TEMPERATURE AND RAINFALL FOR THIRTEEN YEARS FOR THE STATE.

Temperature in degrees Fahrenheit.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1888	24.3	30.5	34.2	49.2	59.1	70.4	72.1	70.4	60.3	47.9	42.9	33.3	49.5
1889	33.3	25.8	40.2	49.9	60.2	66.7	72.5	69.1	62.9	47.9	41.0	43.8	51.1
1890	38.8	39.4	34.5	51.3	59.2	73.3	73.1	68.8	62.1	52.7	43.9	31.2	52.3
1891	33.0	36.0	35.0	52.0	58.0	71.0	69.0	70.0	67.0	51.0	40.0	39.0	51.7
1892	24.0	35.0	35.0	49.0	59.0	73.0	73.0	71.0	64.0	52.0	38.0	29.0	50.1
1893	18.0	29.0	38.0	50.2	58.3	70.6	74.5	70.7	65.2	53.7	39.3	32.7	51.6
1894	37.7	28.9	45.1	50.6	60.0	71.3	74.3	71.2	67.8	53.9	37.5	33.9	52.3
1895	23.4	19.6	35.5	51.7	61.1	72.0	71.6	73.5	69.0	46.9	41.3	33.9	49.9
1896	29.4	30.5	32.4	56.7	67.9	69.5	73.2	71.8	62.7	49.0	45.1	32.9	51.7
1897	25.5	32.4	41.5	49.3	46.3	68.1	75.5	69.4	66.9	58.1	42.2	32.8	50.6
1898	32.4	30.0	45.0	47.2	61.0	71.9	76.0	73.5	67.8	53.1	38.3	28.8	52.1
1899	27.8	21.6	36.9	53.3	63.3	71.5	74.1	73.7	64.1	57.4	43.9	30.2	51.5
1900	31.1	26.0	32.9	50.1	62.9	69.8	74.1	76.3	69.3	60.5	41.6	31.6	52.3
Averages	28.7	29.6	37.4	50.8	59.7	70.7	73.3	71.5	65.3	52.6	41.2	33.2	51.3

Rainfall—Inches.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1888	3.65	1.74	3.55	1.99	3.77	3.41	4.40	5.16	2.27	3.98	4.25	1.47	3.30
1889	3.13	1.35	1.50	1.79	3.71	4.13	4.25	1.50	3.62	1.78	4.02	2.81	2.79
1890	4.94	5.25	5.29	3.15	5.52	4.50	1.99	4.70	5.56	4.27	2.53	2.37	4.17
1891	2.82	4.91	4.19	2.13	2.20	4.82	3.82	3.07	1.50	1.76	5.00	2.39	3.21
1892	2.05	3.27	2.16	2.63	4.63	6.73	3.13	6.15	1.27	0.67	2.62	1.85	3.09
1893	2.56	5.13	2.09	6.37	4.97	3.34	2 49	2.17	1.57	4.24	2.09	2.61	3.30
1894	2.14	2.79	2.16	2.31	4.00	2.05	1.56	1.67	3.31	2.01	2.17	2.98	2.47
1895	4.00	0.69	1.59	2.11	1.80	2.44	2.00	2.96	1.66	1.22	4.11	3.85	2.37
1896	1.67	2.25	3.34	2.78	2.67	4.81	3.11	3.38	5.13	1.20	2.63	1.65	3.29
1897	1.93	3.64	5.17	3.27	3.93	2.85	4.65	2.72	0.78	0.64	6.62	2.39	3.21
1898	5.25	2.32	6.23	2.32	4.10	2.86	3.98	4.50	2.56	3.72	3.17	2.71	3.65
1899	3.01	2.11	4.66	1.68	4.32	2.96	4.18	1.82	2.69	2.14	1.72	3.16	2.87
1900	2.37	3.53	2.35	1.89	2.40	2.99	4.62	3.68	1.76	1.89	4.15	1.24	2.74
Averages	3.04	3.42	3.40	2.65	3.69	3.71	3.78	3.34	2.51	2.27	3.46	2.42	3.11

METEOROLOGY—TABLE V.

MEAN TEMPERATURE AND RAINFALL FOR THE STATION AND STATE FOR 1900 AND FOR THIRTEEN YEARS.

Temperature in degrees Fahrenheit. Rainfall in inches.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Mean temperature at the Station, 1900	30.2	25.0	31.8	47.8	61.5	68.5	72.6	74.0	67.1	58.9	40.6	30.7	50.7
Thirteen years' average temperature at the Station	27.3	27.7	35.3	48.8	57.9	68.1	70.9	69.2	63.4	50.4	39.9	31.7	49.1
Mean temperature for the State, 1900	31.1	26.0	32.9	50.1	62.9	69.8	74.1	76.3	69.3	60.5	41.6	31.6	52.3
Thirteen years' average temperature for the State	28.7	29.6	37.4	50.8	59.7	70.7	73.3	71.5	65.3	52.6	41.2	33.2	5.13
Rainfall at the Station, 1900	2.78	2.74	2.25	1.70	2.23	3.71	5.65	5.97	2.19	2.10	4.30	0.99	3.05
Thirteen years' average rainfall at the Station	3.29	3.14	3.25	2.46	4.19	4.00	4.29	2.92	3.11	2.52	3.50	2.37	3.25
Rainfall for the State, 1900	2.37	3.53	2.35	1.89	2.40	2.99	4.62	3.68	1.76	1.89	4.15	1.24	2.74
Thirteen years' average rainfall for the State	3.04	3.42	3.40	2.65	3.60	3.71	3.78	3.34	2.51	2.27	3.46	2.42	3.11

METEOROLOGY TABLE VI.

SUMMARY BY MONTHS FOR 1900.

	Temperature.											Number of days.							
	Mean.	Highest.	Date.	Lowest.	Date.	Range.	Mean daily range.	Greatest daily range	Date.	Least daily range.	Date.	Clear.	Fair.	Cloudy.	Rain fell .01 or more.	Monthly rainfall.	Average daily rainfall.	Monthly snowfall.	Prevailing wind.
At the Station—																			
January	30.2	54	24	—5	31	59	14.8	30	25	5	13	7	7	17	17	2.78	.09	4.00	S. W.
February	25.0	65	8	—10	27	75	19.0	38	28	4	21	8	3	17	14	2.74	.10	5.80	W.
March	31.8	57	6	—4	17	61	18.7	33	*1	5	30	7	6	18	13	2.25	.07	4.00	N-N.W.
April	47.8	78	29	20	10	58	21.1	40	29	8	17	12	10	8	6	1.70	.06	T	N.
May	61.5	89	16	25	15	64	28.6	43	6—	11	31	17	6	8	8	2.23	.07	T	N. E.
June	68.5	90	24	44	4	46	22.6	37	10	12	1	11	17	2	11	3.71	.12	....	N.
July	72.6	95	4	44	1	51	23.5	38	*2—	5	25	14	12	5	13	5.65	.18	....	N.S.W.
August	74.0	94	7	49	4	45	23.2	35	31	15	27	18	11	2	12	5.97	.19	....	S. W.
September	67.1	89	*3—	41	19	48	23.4	35	19	8	28	22	5	3	8	2.19	.07	....	S. W.
October	58.9	86	6	30	18	56	24.8	38	15	11	7	21	9	1	4	2.10	.07	....	S.
November	40.6	69	1	6	16	63	16.8	35	4	2	20	6	3	21	14	4.30	.14	2.50	S. W.
December	30.7	55	23	11	15	44	12.9	26	21	—6	*5—	6	9	16	12	0.99	.03	4.40	S. W.
Sums and averages	50.7	76.8	....	21	....	55.8	20.6	36	....	8	....	149	98	118	132	3.05	.10	20.70	S. W.
For the State—																			
January	31.1	67	23	—20	29	87	....	41	26	....	....	8	7	16	9	2.37	.08	....	S. W.
February	26.0	80	8	—20	27	100	....	57	9	....	....	6	9	13	12	3.53	.13	....	W.
March	32.9	70	13	—9	12	79	....	49	17	....	....	8	8	15	10	2.35	.08	....	W.
April	50.1	87	29	15	9	72	....	50	29	....	....	14	8	8	8	1.89	.06	....	S. W.
May	62.9	97	15	20	10	77	....	54	6	....	....	18	11	7	8	2.40	.08	....	S. W.
June	69.8	96	*6—	38	30	58	....	50	*7—	....	....	12	11	7	10	2.99	.10	....	S. W.
July	74.1	103	4	38	1	65	....	51	2	....	....	15	12	4	11	4.62	.15	....	S. W.
August	76.3	108	*8—	40	4	63	....	46	*9—	....	....	17	11	3	9	3.68	.12	....	S. W.
September	69.3	100	*10—	33	19	67	....	45	25	....	....	16	9	5	5	1.76	.06	....	S. W.
October	60.5	93	*11—	23	20	70	....	49	20	....	....	18	8	5	5	1.89	.06	....	S. W.
November	41.6	80	7	....	16	80	....	46	23	....	....	8	7	14	12	4.15	.14	....	S. W.
December	31.6	65	22	—2	17	67	....	40	22	....	....	8	7	16	8	1.24	.04	....	S. W.
Sums and averages	52.2	86.8	....	13	....	73.7	....	48.2	....	....	....	143	109	113	107	2.74	.09	....	S. W.

Station. *1 March 12th, 18th. *2 July 2d and 11th. *3 September 1st, 11th and 26th. *5 December 4th, 5th and 21st.
State. *6 June 24th and 26th. *7 June 10th and 13th. *8 August 6th and 10th. *9 August 5th and 31st. *10 Sept. 8th, 9th and 10th. *11 Oct. 3d and 5th.

METEOROLOGY—TABLE VII.

SUMMARY BY YEARS AND GRAND SUMMARY FOR THIRTEEN YEARS AT WOOSTER.

	1888.	1889.	1890.	1891.	1892.	1893.	1894.
At	Wooster.	Wooster.	Wooster.	Wooster.	Wooster.	Experiment Station.	Experiment Station.
Mean temperature	47.3°	48.6°	49.5°	49.6°	48.0°	49.7°	50.6°
Highest temperature	....	91.5 *1	94.5° Aug. 3	99.0° Aug. 8	98.0° July 25	93.° *5	98.° July 19
Lowest temperature	−5° Feb. 9	−5 *2	1.° March 7	0.° March 1	−20.° Jan. 20	−9.° Jan. 11	−7.° Dec. 28
Range of temperature	....	96.5°	93.5°	99.°	118.°	104.°	105.°
Mean daily range of temperature	....	18.7°	18.9°	21.°	19.°	20.2°	22.9°
Greatest daily range of temperature	....	42.° April 23	41.° Jan. 13	42.° Sept. 23	46.° July 7	45.° Aug. 9	45.° July 31
Least daily range of temperature	....	2.° Jan. 6	4.5° *3	4.° Feb. 8	4.° *4	8.° *6	4.° *7
Number of clear days	....	125	109	116	116	96	127
Number of fair days	....	103	119	110	123	164	154
Number of cloudy days	....	137	137	125	98	105	84
Number of days rain fell	....	119	149	119	119	129	130
Total rainfall	38.23 inches	39.87 inches	54.21 inches	38.36 inches	41.46 inches	40.61 inches	30.60 inches
Greatest monthly rainfall	4.54 inches	6.73 in.—July	7.45 in.—Oct.	4.26 in.—June	7.89 in.—June	6.33 in.—Feb.	4.41 in.—May
Least monthly rainfall	1.39 inches	1.36 in.—Oct.	1.74 in.—Dec.	1.95 in.—April	1.37 in.—Oct.	1.38 in.—July	0.76 in.—Aug.
Prevailing direction of wind	S	S	S	S	S. W........	S. W........	S. W........

*1 July 10. Sept. 1. *2 Feb. 23 and 24. *3 Jan. 8 and Sept. 10. *4 March 5, Nov. 1, 3, 25 and Dec. 1 and 18. *5 July 7, 25 and Sept. 7. *6 Jan. 24, Feb. 11, May 26. *7 Dec 1, 28.

METEOROLOGY—TABLE VII—Concluded.

SUMMARY BY YEARS AND GRAND SUMMARY FOR THIRTEEN YEARS AT WOOSTER.

	1895.	1896.	1897.	1898.	1899.	1900.	Summary for thirteen years,
At	Experiment Station.	Experiment Station.	Experiment Station,	Experiment Station.	Experiment Station.	Experiment Station.	
Mean temperature	47.8°	49.6°	49.4°	50.4°	49.5°	50.7°	49.2°
Highest temperature	98.° June 4	93.° Aug. 9	96.° *10	96.° July 3	95.° Aug. 20	95.° July 4	99.° Aug. 8, 1891
Lowest temperature	—6.° *8	—6° Feb. 19	—18.° Jan. 26	—9.° Feb. 2	—21.° Feb. 10	—10.° Feb. 27	—21.° Feb. 10, 1899
Range of temperature	104.°	99.°	114.°	105.°	116.°	105.°	120.°
Mean daily range of temperature	21.8°	19.°	21.5°	20.8°	22.9°	20.6°	20.6°
Greatest daily range of temperature	55.° Oct. 6	43.° May 8	49.° Oct. 5	50.° Nov. 14	52.° Oct. 24	48.° May 6	55.° Oct. 6, 1895
Least daily range of temperature	1.° Nov. 27	3.° *9	0.° Feb. 6	5.° *11	3.° Feb. 18	2.° Nov 20	0.° Feb. 6, 1897
Number of clear days	125	130	124	133	126	149	123
Number of fair days	117	106	123	104	114	98	120
Number of cloudy days	123	130	115	128	125	118	119
Number of days rain fell	102	134	128	134	116	132	126
Total rainfall	31.45 inches	38.47 inches	36.16 inches	47.85 inches	32.93 inches	36.61 inches	39.91 inches
Greatest monthly rainfall	4.21 in. Nov.	8.05 in. July	5.76 in. Nov.	6.79 in. July	5.56 in. Nov.	5.97 in. Aug.	8.05 in. July, 1896
Least monthly rainfall	1 00 in. Feb.	0.71 in. Oct.	0.29 in. Sept.	2.15 in. Sept.	0.53 in. Aug.	.99 in. Dec.	.29 in. Sept., 1897
Prevailing direction of wind	N.	S. W.	N. W.	N.—S. W.	S.	S. W.	S.—S. W.

*8. Jan. 12, 13 and Feb. 5. *9. Jan. 10 and March 8. *10. July 5 and 6. *11. Jan. 21, March 2 and Dec. 18.

METEOROLOGY—TABLE VIII.

SUMMARY BY YEARS AND GRAND SUMMARY FOR EIGHTEEN YEARS FOR THE STATE.

For the State.	1883	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	Summary for eighteen years.
Mean temperature..................	49.4°	50.6°	48.0°	49.6°	51.4°	49.5°	51.1°	52.4°	52.°	....
Highest temperature	98.° Aug. 22	99° *1-	101.° July 21	98.6° July 7	108.° July 18	102.° Aug. 3	99.5° Aug. 31	103.1° Aug. 3	101.° Aug. 10	....
Lowest temperature..	-17.2° Jan. 22	-34° Jan. 25	-31.° Jan. 29	-21.5° Jan. 12	-21.° Jan. 7	-15.° Jan. 27	-13.5° Feb. 24	-4.° March 7	-5.° Mar. 5.	....
Range of temperature............	115.5°	133.°	132.°	120.1°	129.°	117.°	113.°	107.1°	106.°	....
Greatest daily range temp'tre	55.2° Mar. 18	50° *2	58.5° Jan. 30	57.° Dec. 11.	57.° April 11	50.°	53.° Mar. 30	49.5° Apr. 11	50.° *3	....
Average numb'r days rain fell	146	145	148	131	121	125	115	149	120	....
Mean yearly rainfall...............	44.98 inches.	40.19 inches	38.08 inches	36.71 inches	33.63 inches	39.64 inches	33.53 inches	50.33 inches	38.61 inches	....
Mean daily rainfall.................	.123 inch.	.110 inch.	.104 inch.	.100 inch.	.049 inch.	.108 inch.	.092 inch.	.138 inch.	.110 inch.	....
Prevailing wind......................	S. W..........	S. W..........	S. W..........	S. W..........	S. W..........	S. W..........	S. W..........	S. W..........	S. W..........	....

	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	
Mean temperature..................	50.°	50.1°	52.4°	49.9°	51.8°	50.6°	52.°	51.5°	52.2°	50.8°
Highest temperature..............	103°. July 25	102.° June 19	105.° *4	106.° July 20	108.° Apr. 17	113.° July 4	105.° July 1	105.° Sept. 6	108.° *8-	113.° July 4, '97
Lowest temperature........ ...	-25.° Jan. 20	-24.°	-27.° Dec. 29	-24.° Feb. 6	-18.° *6-	-27.° Jan. 26	-20 ° Feb. 3	-39.° Feb. 10	-20.° *9-	-39.° Feb. 10, 1899.
Range of temperature..........	123.°	126.°	132.°	130.°	121.°	140.°	125.°	144.°	123.°	125.°
Greatest daily range temp'tre	-51.° Sept. 25	54.6°	60.° Oct. 19	59.° *1-	53 ° Mar. 25	67.° *7-	....	....	57.° Feb. 9	67.° Sep. 28, 1897.
Average numb'r days rain fell	121	113	150	89	124	110	121	107	107	127
Mean yearly rainfall...............	37.16 inches	39.63 inches	29.75 inches	28.46 inches	39.58 inches	38.54 inches	43.78 inches	34.51 inches	32.87 inches	37.78 inches
Mean daily rainfall.................	.10 inch.	.110 inch.	.080 inch.	.070 inch.	.120 inch.	.100 inch.	.119 inch.	.994 inch.	.091 inch.	.101 inch.
Prevailing wind......................	S. W..........	S. W..........	S. W..........	S. W..........	S. W..........	S. W..........	S. W..........	S. W..........	S. W..........	S. W..........

*1- Sept. 28th and Oct. 1st. *2 Sept. 5th and Dec. 4th. *3 April 27th and 30th. *4 July 18th and 19th. *5 Jan. 15th and Mar. 29th. *6- Feb. 9th, 10th, and 11th.
*7 Sept. 25th and 26th. *8- July 4th, Aug. 6th and 10th. *9- Jan. 29th and Feb. 27th.

PRESS BULLETINS.

The following press bulletins have been issued during the year:

No. 212, July 9, 1900: PRESENT SITUATION IN OHIO WITH RESPECT TO THE RAVAGES OF THE CHINCH BUG. [Fourth Edition.]

The pest is now working its greatest injury in Clermont, Brown, Fayette, Madison, Highland, Clinton and Warren counties, the damage being in the order in which they are named. For this reason, and to meet the present emergency, this bulletin has been prepared by the Ohio Agricultural Experiment Station.

REMEDIAL AND PREVENTIVE MEASURES.

With millions of bugs in his field or swarming from out of an adjoining field, either of his own or his neighbors, what is a farmer to do? Usually it is not until such conditions prevail that the farmer becomes aware that there is a chinch bug within miles of his field, and after having learned of their immediate presence, he almost invariably waits to see what they are going to do, and by the time he finds out, they have become diffused over so large an area as to make any effort to control them rather a stupendous affair. If, then, the bugs are gathered on the outer rows of corn, as is usual in the larger portion of Ohio, they having left the wheat fields for the corn as soon as the grain was harvested, follow the directions given in a circular letter, June 24, 1895, by Prof. S. A. Forbes, State Entomologist of Illinois, which is as follows:

"Dissolve one-half pound of hard or soft soap in one gallon of water, and heat to the boiling point. Remove from stove and add two gallons of coal oil, churning the mixture with a good force pump for fifteen minutes. When the emulsion is formed, it will look like buttermilk.

"To each quart of this emulsion add fifteen quarts of water, and apply to the corn in a spray—preferably before 10 A. M. or after 3 P. M. The bugs should be washed off so that they will float in the emulsion at the base of the plant. A teacupful is generally sufficient, but the quantity must vary with the number of bugs infesting the corn."

That the above is effective and of practical value, we know from personal experience, and many fields in central Ohio can be thus protected, if the effort is made to do so and at the proper time.

If the bugs have taken possession of more than one of the outer rows of corn, put in the plow and turn under a strip along the edge where the bugs were congregated, promptly harrow it down smooth and roll or pack the surface of the ground with a clod crusher. Bury a chinch bug under three or four inches of soil and it will not crawl out, as I have learned by actual experiment in the field. This applies to corn; there is no way of treating the pest in the wheatfield or meadows. I once tried to use the emulsion among wheat, drenching the small patches of whitening straw when these began to show in the field, but could not see that any good resulted from the application.

So far as remedies are concerned, then, we can only recommend the use of kerosene emulsion, and in more serious cases the plowing of the infested area followed by harrowing and rolling.

In case a migration is in progress from a wheatfield to a cornfield, if about three deep furrows are plowed as closely side by side as possible, the invasion may be stopped. A few bugs will get in and climb out of the first furrow, but less will succeed in passing the second, while the third will stop about all of these. If there are so many that they seem to be escaping after a few days fill up the trenches with a plank clod crusher or scraper, level off and roll, making new furrows where the ridges were between the old furrows, and you have a new series of obstructions.

A combination of the trench and emulsion measures has been tried this year with perfect success. A deep furrow was plowed and cleared out and when it became well filled with bugs and as soon as any began to cross it, it was thoroughly drenched with the kerosene emulsion and all that had fallen into it were quickly killed.

If the outer rows of corn are grown up with foxtail or panic grass, the bugs will largely remain on that in preference to going farther, or if a strip of millet be sown along the margin between the two fields, so as to have it up several inches by the last of June, or about harvest, this will cause a halt in the migrating hordes, and keep them engaged in feeding on the growing millet until the food supply begins to fail, when they will move onward. If about this time the farmer will put in his plow and turn under bugs, grass and all, and harrow and roll the ground, he will leave so few bugs above ground that they will cause little if any injury. This has been tried where the strip of millet was displaced by foxtail and panic grass, and we know that it will work effectually.

Where neither of the foregoing measures are practicable, and a prompt defense is necessary, a barrier of tarred boards may be used, and a mixture of nine parts of coal-tar and one part linseed oil, thoroughly mixed and spread upon boards either laid flat on the ground, or placed on edge and the upper edge daubed with the mixture. Where the line of defense is not too long, and one has the boards at hand, this may serve to hold the bugs in check for a time, but if one is obliged to purchase the lumber the expense will be a serious objection. In some cases a ridge has been thrown up and made smooth and compact on top, the tar mixture being applied on this in a train with a watering pot without the sprinkling attachment. The trouble here is that the wind blows the dust over this train of oil and tar, soon crusting over the surface so that the bugs crawl over it without sticking fast. If taken in time the application of kerosene emulsion will stop an invasion in a cornfield, while if ground over which the bugs are passing is plowed and the vegetation thoroughly covered, so that the bugs may not, by following the grass and weeds, make their way to the surface, the more serious invasions may be overcome. It is not necessary to destroy every individual bug, and if the number has been reduced so as to ward off material injury, then the object has been accomplished.

THE CHINCH BUG FUNGUS.

With favorable meteorological conditions, the threadlike branches of the fungus will take possession of the interior of the bug. When the bug dies, branches are pushed out through the body and produce clusters of minute capsules filled with spores. Sometimes these clusters are so thick on the dead bugs as to almost obscure the body, and only the legs are visible, or the bugs may be clustered on a plant, dead and covered with fungus. Now, as these capsules containing the spores burst, they release the spores and these may be still further diffused by the wind, so that it is easy to see how one diseased bug among a mass of several hundred may affect the whole of them, and if some of the infected ones, before becoming helpless, stray to a distance, the infection is carried from place to place and in this way diffused from field to field. Thus it will be observed that however easily

large masses of bugs may be destroyed by this fungus enemy, under favorable conditions, the prospect of its working is not very encouraging if either the bugs are badly scattered or the weather is dry.

DIRECTIONS FOR USING THE FUNGUS.

We are sending out this fungus this year, cultivated artifically in a mixture of beef broth and corn meal, which saves much time and expense in securing and transporting the bugs to and from the Station. *Those who receive this are instructed to cut the mass contained in each box into bits the size of an ordinary pin head and drop these bits among the bugs, where these are massed in greatest numbers, preferably on low or damp ground.* The other measures should on no account be neglected.

F. M. WEBSTER, *Entomologist.*

No. 213, July 22, 1900: A SEVEN-YEAR COMPARISON OF VARIETIES OF WHEAT.

About sixty differently named sorts of wheat are annually grown in comparative test at the Ohio Experiment Station. In this test the different varieties are grown on plots of one-tenth acre, the plots being arranged so that a standard variety, Penquit's Velvet Chaff, appears on every third plot in the series, and in computing the results the yield of a given variety is compared with that of the two plots of Velvet Chaff between which it grew.

The treatment of the crop is as nearly uniform for all the varieties as possible. The land was selected in the first place for its apparent uniformity; a tile drain is laid at one side of every plot; the plowing is done across the plots; all are manured alike with barnyard manure, distributed by a manure spreader, which also is driven across the plots, thus giving no opportunity for differences in time of plowing or manner of manuring to affect the yield, and the greatest possible care is taken in seeding, harvesting and threshing.

Below are the general results of this test for the seven years, 1893 to 1899, inclusive.

The following sorts have exceeded the Velvet Chaff in yield: Poole and Mealy by an average of more than four bushels per acre each; Red Russian by nearly four bushels; Nigger, Early Ripe, Currell's Prolific, Gypsy, and Egyptian by two to three bushels; Mediterranean, New Monarch and Democrat by one to two bushels, and Bearded Monarch, Valley, Deitz, Lebanon, and Hickman by less than one bushel each.

Of the sorts which have fallen below Velvet Chaff in average yield are Jones' Winter Fife, which has averaged more than three bushels less; Theiss and Silver Chaff, between two and three bushels less; Royal Australian (or Clawson), Early Red Clawson, Yellow Gypsy, Missouri Blue Stem, New Longberry, Lehigh and Martin's Amber between one and two bushels less, and Fulcaster, Hindostan and Early White Leader, whose average yield has been less than a bushel below that of Velvet Chaff.

These tests have been made on a rather thin, somewhat sandy clay. On gravelly loams the Valley has made a relatively larger yield than that quoted above.

No variety has proved exempt from attack by the Hessian fly, but Mealy, Mediterranean, Fulcaster and Clawson seem to suffer less from the fall attack of this insect than most other sorts.

The Ohio Station has never succeeded in growing spring wheat.

No. 214, July 30, 1900: A WARNING AGAINST FRAUD.

The Ohio Experiment Station has just received the following letter from Marion County:

"There is a company of men canvassing this territory for fruit trees. They are putting in what they call a 'model orchard.' They claim to be working

directly for and in the interest of your station, which gives them quite a leverage with a great many farmers."

To this letter we reply that this Station sells no fruit trees of any description, and all persons who claim to represent it in the manner indicated are swindlers and should be arrested for obtaining money under false pretenses.

No. 215, August 13, 1900: SUGGESTIONS TO WHEAT GROWERS.

The almost unparalleled destruction of the wheat crop of 1900, throughout Ohio, Indiana and Michigan, is generally ascribed chiefly to the Hessian fly, and undoubtedly this insect has caused much loss, not only by destruction outright of many plants in the fall, but by so weakening the vitality of others that they succumbed to weather conditions which they would otherwise have been able to resist. But behind these causes there lies another which must not be lost sight of, namely, the exhaustion of soil fertility. The importance of this factor is shown in the experiments of the Ohio Station, in which wheat on new land has, this year, yielded nearly 40 bushels to the acre, without fertilizers, whereas unfertilized wheat on land that has been, for 60 or 70 years, under such cultivation as is practiced on a large proportion of Ohio farms, was almost totally destroyed by fly and weather conditions combined, the number of plants attacked by the fly being in both cases approximately the same.

Where the sowing of wheat has been delayed until after the middle of September in the extreme northern part of the State; to the 20th or 25th in the latitude of this Station; to the last week in the month in that of Columbus, and to the first week in October farther south, the results have been generally more favorable than where the seeding was done earlier; but these dates were not sufficiently late to escape the fly last fall, owing probably in part to peculiar seasonal conditions. When the seeding is delayed beyond the dates mentioned the loss from the plant not having time to sufficiently prepare for the winter will probably be greater than the average loss from the fly.

Even at these dates, in ordinary seasons, there will be need to see that the land is thoroughly prepared and well fertilized if remunerative yields are to be obtained.

Late sowing, however, while in some measure a protection from the fall attack of the fly, will have no effect on the spring attack unless universally practiced in a given district; for if one farmer in a township sows his wheat in time to invite the fall attack he will have provided a breeding place from which flies will swarm the following spring to destroy the crops of all his neighbors. It would seem, therefore, to be well worth while for farmers to take united action in this matter by banding together over large districts and agreeing to delay their wheat seeding until the dates suggested. Such a test, if properly carried out, would be of incalculable value in determining the actual value of this method of securing immunity from the fly.

If, in connection with a general postponement of the date of seeding, each farmer would sow a small strip of wheat at an earlier date, this to be plowed under with a jointer a few days before the general seeding and then resown, it might have a very useful effect in attracting the flies and causing them to deposit their eggs where they could be easily destroyed.

Many farmers are writing to the Experiment Station, asking whether it is advisable to sow rye instead of wheat this fall. To this we have to reply that rye is also subject to attack from the Hessian fly, while the statistics of crop production in Ohio show that the average yield of rye is no greater than that of wheat, and the market statistics show that its average value per bushel is much below that of wheat.

Our advice therefore is, in brief: Put the seed bed for wheat in the best possible condition by plowing early, thoroughly pulverizing the surface immediately to

retain moisture, and manuring or fertilizing liberally; then delay the seeding to a comparatively late date and use a liberal quantity of seed. The recent experiments of this Station show that two bushels of thoroughly cleaned seed is not too much for an acre of ordinary land.

No. 216, August 27, 1900: FERTILIZERS ON WHEAT.

In the tests of the Ohio Experiment Station, phosphoric acid, in the form of acid phosphate, has been decidedly the chief factor in producing increase of crop during the season just past. A similar result has been reached by many farmers, and the natural consequence is a general tendency to limit the use of fertilizers the coming season to plain acid phosphates; a tendency strengthened by the fact that the phosphates are not so completely under the control of the fertilizer trust as are the mixed fertilizers.

When, however, the experiments at the Ohio Station are studied as a whole, taking not simply the effect upon the present season's wheat crop, but the average results upon wheat, corn, oats and grass for the past seven years, it will be seen that it would be a decided mistake to base conclusions upon this one wheat crop alone.

In the experiments of the Central Station at Wooster, where wheat has been grown in rotation with corn, oats, clover and timothy, the average increase per acre from plain acid phosphate, applied at the rate of 160 pounds per acre to wheat and eighty pounds per acre to corn and oats, or a total of 320 pounds during the five years of a rotation, has been 4.6 bushels of wheat, 3.6 bushels of corn, 7.2 bushels of oats and 500 pounds of hay, while from the same quantity of acid phosphate, carried partly in acid phosphate and partly in tankage, but re-enforced by the nitrogen carried in the tankage and by a small addition of muriate of potash, the average increase has been 7.2 bushels of wheat, eight bushels of corn, eight bushels of oats and 1600 pounds of hay.

The cost of the acid phosphate used on an acre in five years has been about $2.40, while that of the mixture of acid phosphate, tankage and muriate of potash, has been about $3.75; but the average increase from this mixture has been so much greater than that from acid phosphate alone as to give a total net profit, over the cost of the fertilizer, of about $12 per acre in five years for the mixed fertilizer against about $6 for the acid phosphate used alone.

In mixing this fertilizer "seven and thirty" tankage and fourteen per cent. acid phosphate are used in equal quantities, adding about 100 pounds of muriate of potash to the ton. This gives a fertilizer analyzing over three per cent. ammonia, ten to twelve per cent. phosphoric acid and two and one-half per cent. potash, and may be made up at a cost of $18 to $20 per ton.

No. 217, September 10, 1900: TUBERCULOSIS IN CATTLE.

By act of the last General Assembly of Ohio, the Agricultural Experiment Station is charged with the duty of conducting investigations to determine the prevalence and best methods of prevention of tuberculosis and other diseases of cattle throughout the state. In accordance with this provision the Station has employed a veterinarian to assist in carrying out the work thus authorized.

This work is simply one of research and education; in conducting it the Experiment Station has no authority to go upon any man's premises to inspect his cattle except upon his invitation; it cannot require him to destroy any animals except by mutual agreement, nor can it offer him any compensation for the loss of cattle from tubercular or other diseases.

The Experiment Station is able, however, to offer the assistance of the Station Veterinarian in the prevention and control of bovine tuberculosis, and through the co-operation of Dr. D. E. Salmon, Chief of the Bureau of Animal Industry, United States Department of Agriculture, it is enabled to include the tuberculin diagnosis in this offer, under the following conditions:

Whenever evidence satisfactory to the Experiment Station is furnished that tuberculosis probably exists in a herd of five or more cattle within the state, the Station will test the entire herd with tuberculin, such test to be free of all cost to the herd owner except the board of the Station's agent while making the test (about two days for every herd of twenty animals or less) and his transportation to and from the nearest railway station. In some cases it may be possible to include two or more small herds, or several single animals, in a single test, by having these animals so placed near together that they may be easily tested.

In the ease of the state and county benevolent institutions, children's homes especially, the Station offers to make an annual tuberculin test of their herds without requiring any evidence of the appearance of tuberculosis as a prerequisite to such a test, the only requirement being the board and transportation of the Station's agent, as above mentioned.

When animals are found which show external evidences of the disease the owner will be advised to destroy them at once, as such animals are centers of infection to those around them and thus are sources of increasing loss. In the case of apparently healthy animals which react under the tuberculin test, the advice of the Station will be that they be slaughtered for beef under Governmental inspection, first fattening them for a few months if necessary. Experience has shown that fat and apparently healthy animals are occasionally found, on slaughter, to be in advanced stages of tuberculosis; but that many of the animals which react to to the tuberculin test when first made in a tuberculous herd, will be found to be in the incipient stages of the disease only, and these may be safely used for food if slaughtered under proper inspection, whereas if permitted to remain in the herd, they will soon become too far diseased to be thus used and will, moreover, become distributors of the infection.

When cattle are held in order to prepare them for slaughter, they should be kept entirely separate from all other animals—horses, sheep and swine as well as cattle—and the milk produced by them should be thoroughly sterilized before being used as food.

In the case of valuable pure bred cattle, the Station will advise the holding of slightly affected females until after dropping their calves, which should be at once taken from their dams and fed upon the milk of healthy cows.

That the cleaning out of a tuberculous herd may be effectual, the Station will recommend thorough disinfection of stables, and will give instructions in this work.

By the methods above indicated—destruction of a few badly diseased animals, and slaughter under inspection of a larger number which were found to be only in the first stages of the disease, followed by thorough disinfection of the stables, and feeding the calves upon the milk from healthy cows, or that which had been sterilized, this Station has built up in three years a herd of apparently healthy cattle upon a foundation in which nearly half the animals were found to be tuberculous. It is therefore with great confidence that we recomend this method to the cattle owners of Ohio and offer our services in carrying it out.

It should be distinctly understood that the Station does not propose to advertise the presence of tuberculosis in any particular herd of cattle. Its work, as stated above, is confined to investigation and to the rendering of assistance to the cattle owners of the state in ridding their herds of this destructive and dangerous disease, and this work will be so conducted as not to necessarily increase the misfortune of having the disease in the herd.

The Station cannot make inspections of breeding cattle for certification purposes. Where such inspection is desired, application should be made to local vet-

erinarians, accredited by the Secretary of the State Live Stock Commission, Dr. D. N. Kinsman, Columbus, O.

The foregoing offers are subject to modification or withdrawal at any time.

No. 218, September 17, 1900: ANNOUNCEMENT CONCERNING SUGAR BEETS.

The Ohio Agricultural Experiment Station has just mailed to the growers who received seed from the Station last spring, its announcement as to beet samples. Franked shipping tags, sampling directions and other descriptive blanks will be mailed to them about October 15th; growers will refrain from sending beet samples until after that time. These franked tags will carry packages not exceeding four pounds in weight by mail, free. As heretofore, the Chemical Department of the Experiment Station will analyze free of charge the sugar beet samples grown from the seed it distributed, when these are accompanied by proper description of the sample of beets.

Persons who have other sugar beets than above stated may arrange for analysis of them by writing to the Experiment Station, Wooster, O., before sampling. The Station declines to receive sugar beet samples by express unless charges are prepaid.

No. 219, November 26, 1900: OHIO SUGAR BEET WORK FOR 1900 AND 1901.

RESULTS OF SUGAR BEET INVESTIGATIONS IN 1900.

About 900 pounds of imported sugar beet seed of four varieties was supplied to the Ohio Agricultural Experiment Station by the United States Department of Agriculture for tests in the state during 1900. About 150 pounds additional was contributed by others. This seed was distributed to 203 applicants in sixty counties. In distribution, 107 of these recipients were in the northern section of the state; fifty-seven in the middle and thirty-nine in the southern. The seed was nearly all sent out during March, 1900, so that early planting could be made.

The analyses have now been completed by the Chemical Department and 286 samples are included, of which 209 are from the northern, fifty-seven from the middle, and twenty from the southern section. As heretofore the northern section shows the best results, or 11.4 per cent. sugar in the beet and a purity of 77.9. For the entire state the sugar in the beet is 11.0 per cent., and the purity 77.1.

SUMMARY OF RESULTS OF OHIO SUGAR BEET ANALYSES IN 1900.

Section.	Number of samples.	Average weight of Beets, ounces.	Sugar in Beets, per cent.	Purity coefficient
Northern section	209	13.4	11.4	77.9
Middle section	57	19.7	10.9	77.5
Southern section	20	12.5	8.1	67 8
Entire state	286	13.8	11.0	77.1

On the whole the beets, previous inference to the contrary notwithstanding, are below those of last year in sugar content and purity, few counties that supplied a number of samples giving the factory requirement, an average of 12 per cent. sugar in the beet, and a purity of 80.0.

In 1899 the midseason was dry, while in 1900 this period was one of abundant rains; in both years the fall was warm and summer like. It would appear that the rainy season was less favorable to rich beets than the dry period of 1899.

The bulletin giving results in full detail will be ready in January, 1901, and may be obtained upon request.

SUGAR BEET SEED FOR 1901.

The Ohio Experiment Station is again assured of a limited supply of beet seed, for use in Ohio, to be imported by the United States Department of Agriculture. Judging by our past experience as well as that of others, the season of 1900 was favorable to a good stand of beets; this applies to favorable soil and weather conditions. With this experience we again urge preparation of the soil intended for beets by fall or winter plowing *and subsoiling*, and that beet planting be done as early as practicable, say in March and April.

While the Experiment Station is unwilling to discriminate between citizens who may apply for seed in accordance with this announcement, it cannot advise farmers in the southern and middle sections of the state to pursue tests in growing sugar beets, since these sections, with the possible exception of the extreme northern counties of the middle area, are so much less favorably situated for beet growing than the northern section that the establishment of a successful beet-sugar industry in them is highly improbable. Experiments in the northern section are much more likely to lead to the establishment of successful beet-sugar factories. There is now a factory at Fremont, Sandusky county, drawing its supply from 2,700 acres chiefly in that and the adjacent counties, and to a limited extent in Henry and Defiance counties. A freight rate of 75 cents per ton is paid on some of these beets for a distance of about fifty miles including one transfer of roads. Any farmer, therefore, who is not more than sixty to seventy-five miles from Fremont could gain even more valuable experience by contracting for the minimum average with that factory and thus realize actual commercial experience with beets. This course is suggested for those in reach of the factory.

Thus by more concentration of effort in other portions of the northern section where beet growing promises to be more profitable, more good can be accomplished than by doing as in the past. With the establishment of this industry in Ohio, it is altogether likely that after 1901 the Station may change its form of sugar beet investigations to suit the altered conditions.

The Ohio Experiment Station is now ready to receive applications for sugar beet seed intended for planting in 1901.

Application cards are mailed to growers with this announcement and will be sent to others upon postal card request. It is the purpose to send out the beet seed in March, 1901. The amount sent to any person will be limited to twelve pounds.

No. 220, February 25, 1901: SEEDING LAWNS AND PERMANENT PASTURES.

Many inquiries are received at the Ohio Experiment Station for information respecting the best grasses for lawns and permanent pastures and for instructions in seeding. The Station has successfully established several lawns by the following method: As soon as the ground is dry enough to work in the spring it is plowed and thoroughly pulverized by harrowing and cross-harrowing until in the condition of a garden. Unless the soil is very rich it should be made so, either by the liberal use of manure or of a complete fertilizer, the latter being preferable because of the seeds of weeds and coarse grasses usually carried in manure. For lawn purposes the fertilizer should carry 4 to 6 per cent. nitrogen, 8 to 10 per cent. phosphoric acid and 6 to 8 per cent. potash, and should be used at the rate of 600 to 800 pounds per acre.

A mixture of equal weights of Kentucky Blue Grass and Red Top, with a pound of white clover seed to a bushel of the mixture, is then sown broadcast, at the rate of two or more bushels per acre of the mixed seed, and harrowed in with a fine-toothed harrow. If the ground should be very dry it may be rolled as part of the preparation for sowing, but the finishing touch should always be given with a smoothing harrow, or other fine-toothed harrow, as this leaves the surface in such condition as not to be so liable to be injuriously packed by rain as if finished with the roller.

The reason for mixing the Kentucky Blue Grass with Red Top is that the two grasses mature at different seasons, the Red Top reaching maturity some weeks later than the Blue Grass, thus keeping up a better succession through the season, while the Blue Grass is better adapted to the dryer and the Red Top to the moister portions of the land. The clover is not only useful in thickening the sod, but by its ability to gather nitrogen it assists the growth of grasses with which it is sown.

For permanent pastures no better grasses have been found by the Ohio Station than the varieties above recommended for lawns. Sown together they give a succession throughout the season and adapt themselves to differences in soil, thus giving much better results than if either be sown alone. The seed of these grasses is relatively expensive, however, and it is more economical to reduce the quantity of seed of these varieties and substitute a moderate quantity of red clover and timothy seed. The first year after seeding, the crop may be chiefly clover, and should be mown for hay. The second year it will be chiefly timothy, and after that the timothy will gradually disappear and the pasture grasses take its place. By this method of seeding not only will the first cost be reduced, but the clover will serve a most useful purpose in preparing the way for the grasses which are to follow. A mixture of equal weights of clover and timothy, sown at the rate of a bushel to six or eight acres, and cross sown with half a bushel to a bushel to the acre of mixed Blue Grass and Red Top, the whole harrowed in together, will make a fair seeding. In the case of pastures, as well as of lawns, the land should be manured or fertilized if not already rich, and here manure is the better material, if it can be obtained.

All old pastures or lawns should have an occasional dressing of manure or fertilizer. The object lessons in the scattered cattle droppings on the pastures demonstrate this point effectively. Such treatment will often thicken up the grass in an old lawn without reseeding, but if bare spots have made their appearance it will sometimes assist matters to apply a dressing of air-slacked lime, at the rate of a bushel to the square rod, work it into the surface with a sharp harrow, and after a few weeks reseed as for a new lawn.

No. 221, March 4, 1901: A BULLETIN ON PLANT DISEASES.

The discovery that the smuts, mildews, rots and other diseases which cause such enormous losses every year are largely due to the growth of fungous parasites is a matter of recent date, and no part of the work undertaken by the agricultural experiment stations has yielded results of greater practical value than the demonstration that many of these diseases may be controlled by methods within easy reach of the ordinary farmer and fruit grower.

This work has been going on for ten or twelve years past. Its results are scattered through a multitude of bulletins, many of which are now out of print, or are unknown to the ordinary reader. For this reason the Ohio Experiment Station has collected, in a single bulletin, the chief results of its own work and that of other similar institutions, under the title: "A Condensed Handbook of the Diseases of Cultivated Plants in Ohio." This bulletin, No. 121, contains a brief description of the general characteristics of parasitic fungi, followed by an alphabetical list of the plants in ordinary cultivation, with the diseases to which they are most subject, and suggestions for treatment.

The bulletin also contains a reprint of the "Spray Calendar," originally published by the Station at the request of the State Horticultural Society. The object of the bulletin is to give descriptions of the various plant diseases sufficiently full to enable the non-technical reader to recognize them readily. It contains numerous illustrations of disease forms, and its many references to original publications serve as a very complete index to the literature of this newest of the branches of applied science.

No. 222, March 11, 1901: TUBERCULOSIS OF CATTLE.

As announced last Fall, the Ohio Experiment Station is prepared to apply the tuberculin test to cattle suspected of being affected with turberculosis, the test being made without cost to the owner of the cattle, except the board of the Station's agent during the two days required to make the test, and his transportation to and from the nearest railway station.

Under this offer the Station has thus far tested thirteen herds, containing 279 cattle, with the result that six herds were found to be entirely free from turberculosis, while in the remaining herds there were eighteen cases of positive reaction to the tuberculin test. Five of these eighteen cattle were immediately killed by their owners and examined by the Station Veterinarian, the result of the autopsy confirming the accuracy of the tuberculin diagnosis in every instance. In other cases the owners have been advised to fatten the animals, in the hope that the disease would prove not to have become sufficiently generalized to affect the meat.

It will be observed that nearly half the herds examined proved to be entirely free from disease. One of these herds belonged to a children's home, and others were dairy herds in which occasional coughing or other temporary indisposition had caused some anxiety. In four other cases only one or two animals were found affected, and the owners were enabled by the test to at once separate such animals from the herd, distinfect their stalls, and probably prevent further spread of the disease.

No doubt many persons hesitate to subject their herds to this test for fear of exciting public suspicion; but it is no part of the Station's duty or intention to advertise the presence of this disease in any particular herd.

IS THE TUBERCULIN TEST INJURIOUS?

Others are probably deterred through fear of the test itself producing an injurious effect on the tested cattle; but on this point the evidence is conclusive that no such effect follows this test. At the Ohio Station eight cattle were subjected to the tuberculin test during the period from June, 1897, to April, 1899, the tests being repeated at intervals of a month during the latter part of this period. These cattle had all reacted to the tuberculin test at the beginning of the experiment, but as it progressed the reactions became more and more irregular and finally ceased altogether, notwithstanding a considerable increase in the dose of tuberculin. Some of these cattle were under three years old, others were cows and a bull of various ages. The young cattle kept fat and grew rapidly, the older ones constantly increased in weight, and when slaughtered the evidence presented indicated that if the tuberculin injections had had any effect upon the health of the animals it had been beneficial rather than otherwise. All the cattle at this Station are now tested regularly every six months, and animals which have been subjected to these tests for four years are still in the best of health. Altogether, this Station has made many hundred of tuberculin injections, with never a suspicion of any injurious effect. On the other hand, we have abundant encouragement to believe that we are building up a herd of healthy cattle, a large portion of which are the offspring of tuberculous parents.

At the Maine Station ten cattle received tuberculin injections at intervals of a few days to a few months from 1895 to 1897, as many as twenty-four injections being given in some cases. The results were similar to those reached at the Ohio Station.

At the New Jersey Station a herd of tuberculous cattle was kept under observation for six years, the animals receiving from eight to nineteen injections each during that period, but no evidence was found to justify the assertion that the general health, even of non-tuberculous cattle, had been affected, either for better or for worse, by the treatment.

Prof. H. W. Conn, of the Storrs Experiment Station of Connecticut, spent a year in Europe, making a special study of cattle tuberculosis and the tuberculin test. He reports that those who have had the largest experience in the use of this test say that there is absolutely no reason for believing that it is followed by any injurious results.

The Station's object in offering its services in this work is to assist farmers, breeders and dairymen in freeing their herds from a disease which, if permitted to continue unchecked, will inevitably cause great financial loss, as well as endanger the lives of those who may consume the milk produced.

No. 228, March 18, 1901: ALFALFA.

The correspondence of the Ohio Experiment Station indicates a large and increasing interest throughout the state in the culture of alfalfa. On the thin clays of the Station farm the results of the experiments thus far made with this plant have not been encouraging; but there are large areas within the state where heavy sheets of drift clay are found, which, when underdrained, should produce this crop to advantage. Again, there are other regions of well drained, black soils and rich, upland clays and bottom lands, which are naturally drained by underlying gravels; these offer conditions that have been found most favorable to alfalfa. Mr. Joseph E. Wing, of Mechanicsburg, Ohio, whose land is of the kind last mentioned, has grown alfalfa on a large scale and with excellent success, and he has furnished the following hints as to its culture:

"The best way to sow alfalfa is to plow the land deep in the spring or winter. Turn up a little new soil; harrow down and sow beardless spring barley at the rate of two bushels to the acre. Sow fifteen pounds, or a peck, of alfalfa seed at the same time. I usually roll the land well after sowing. This makes the alfalfa do better but is sometimes hard on the barley. Alfalfa will come up through very firm soil and thrive better than when it is too loose. Let the barley ripen and cut it for grain. Then when the alfalfa starts up a little clip it with the mower. Clip it close. It will start again and after a month or so clip again. Keep the stock all off until next year. It is better to keep stock off for two years. Begin mowing the second year as soon as blossoms form. After the first crop is taken off it will mature another in exactly thirty days. Do not delay cutting this second crop. It will take about thirty-five days for the second crop to grow. Take it off promptly Then in thirty-five or forty days there is the fourth crop. Take it, or graze it.

"The third year is the best in the alfalfa's life, though it may not decline for ten years. Keep all stock off it after frost; it is deadly then. Stock injures it greatly by treading on it after it is frozen. Do not pasture it close either in summer. It is the best pasture on earth for pigs, horses, cows, sheep and chickens, There is the same difficulty regarding bloat that there is in red clover. After frost there is perhaps more danger; yet the danger is slight if the stock, after being used to it, are never taken away from it until frost and are then taken away for good.

"There is a point of great importance in the growth of alfalfa, and it is responsible for half the failures; poor soil is responsible for most of the rest. This point is the leaf blight, or rust. If alfalfa is left standing too long there comes on the leaves a reddish rust. This rust causes the leaves to fall. Then the stem becomes woody and the hay is of little value, and if it is not cut there will not be any growth of consequence. As soon, therefore, as this rust is seen, the alfalfa must be cut, and it must be cut no matter if it is a small growth. It will, as soon as it is cut, start to grow vigorously again. This rust will not form in less than about thirty days. That gives the alfalfa time to make a crop.

"Another point: During a dry time the growth may be short. Cut it just the same when the time comes. It will then be ready to take advantage of a rain and make the next crop. If you have not cut it and the rain comes it will not grow. The lesson is, cut it on time whether it is little or big.

"NOW FOR A FEW 'DON'TS:'

"Don't sow alfalfa on poor soil.

"Don't sow alfalfa on wet soil.

"Don't forget to clip it three times the first year.

"Don't turn any stock on it until the next May.

"Don't let alfalfa hay get dry before raking.

"Don't fail to cut your hay in time. That means to be ready to cut by June first.

"Don't ever let stock on your alfalfa meadows in cold weather.

"Don't sow alfalfa seed on unprepared soil, as you do clover.

"If it fails with you, manure the land and try again."

No. 224, May 27, 1901: TREATMENT FOR THE CANKER WORM.

It is now too late to begin treatment, this season, for the canker worm, on badly infested orchards, but there are many orchards in which the worms are not numerous where considerable future work might be saved by spraying at once. The only way to combat this pest successfully is to begin spraying before the trees bloom, but in case it is just making its appearance in an orchard, late spraying may do considerable good, but the work must be done while the worm is still feeding. Orchards which are supposed to be free from the pest, but are near infested trees, ought to be watched carefully late in May and early in June, for when the worms destroy the foliage on trees where they are numerous they will travel along fences for considerable distances to other orchards.

Thorough spraying with some of the forms of arsenic recommended below will destroy the worms, but it should not be expected that one application will kill all. It may take several seasons' work to accomplish the desired result, but there can be no doubt but the pest may be held in check by using the means advised.

Inasmuch as Bordeaux mixture, which consists of four pounds each of lime and copper sulfate to a barrel of water, is needed for apple scab and other fungous diseases, the most economical plan is to spray with this mixture, adding sufficient poison to kill the worms. Half a pound of Paris green to a barrel of mixture will answer, provided the Paris green is pure. Three or four pounds per barrel of Disparene, a proprietary article stated to contain arsenate of lead, may be better for the reason given below. A cheaper form of arsenic is found in the arsenite of soda, which is made by taking two pounds of commercial white arsenic and four pounds of carbonate of soda to two gallons of water. To dissolve these materials they are boiled together for about fifteen minutes. Take one quart of solution to a barrel of Bordeaux. If it is desired to use poison alone, either arsenate of lead or Disparene is preferable, because neither injures the foliage. Arsenite of soda, if used alone, is very injurious to foliage and Paris green is quite likely to do harm, but either may be safely used in Bordeaux mixture. Two or three sprayings during the season are quite necessary to hold the canker worm in check, and even more to rid a badly infested orchard of the pest. As a rule, all that can reasonably be expected is to be able to hold it in check.

Disparene and arsenate of lead may be procured through druggists or through he publishers of the Ohio Farmer, Cleveland, O.

PUBLICATIONS OF THE OHIO EXPERIMENT STATION.

The first six annual reports of this Station, for the years 1882 to 1887, inclusive, contain the full record of its work during that period. Such bulletins as were published during these years ("First Series") were intended for newspaper use; they were afterward incorporated in the annuals and no copies of the bulletins can now be furnished. The first and second annual reports are also out of print.

The "Second Series" of bulletins began with 1888. The first seven of these were included in the seventh annual report, and cannot be furnished separately. The bulletins published since 1888 are listed below.

No. 8 (Vol. II, No. 1, 1889)—Insects, insecticides and methods of collecting and studying insects. *Out of print*

No. 9 (Vol. II, No. 2, 1889)—Colic of horses, *Out of print.*

No. 10 (Vol. II, No. 3, 1889)—Silos and ensilage. Silage and field beets as food for cows. *Out of print.*

No. 11 (Vol. II, No. 4, 1889)—Experiments with small fruits. Effects of early and late picking upon keeping quality of apples. *Out of print.*

No. 12 (Vol. II, No. 5, 1889)—Wheat: Cultural and variety tests. *Out of print.*

No. 13 (Vol. II, No. 6, 1889)—Remedies for plum curculio and striped cucumber beetle. Notes upon strawberry root-louse, grain plant-louse and little known injurious insects. Prevention of potato rot. *Out of print.*

No. 14 (Vol. II, No. 7, 1889)—Cabbage and cauliflower, and treatment of certain plant diseases. *Out of print.*

No. 15 (Vol. II, No. 8, 1889)—Eighth annual report. Meteorological summary. Index.

No. 16 (Vol. III, No. 1, 1890)—Experiments with potatoes.

No. 17 (Vol. III, No. 2, 1890)—Field experiments with fertilizers.

No. 18 (Vol. III, No. 3, 1890)—Experiments with corn and oats. Actinomycosis.

No. 19 (Vol. III, No. 4, 1890)—Spraying to prevent insect injury. Insects affecting corn. Fungous diseases of plants. Collecting plants. *Out of print.*

No. 20 (Vol. III, No. 5, 1890)—Corn silage vs. sugar beets as food for milk production.

No. 21 (Vol. III, No. 6, 1890)—Wheat: Cultural and variety tests

No. 22 (Vol. III, No. 7, 1890)—Strawberries and raspberries.

No. 23 (Vol. III, No. 8, 1890)—The plum curculio, cucumber beetle, rhubarb curculio and clover stem borer. Potato blight.

No. 24 (Vol III. No. 9, 1890)—Asparagus. Transplanting onions.

No. 25 (Vol. III, No. 10, 1890)—Grape rot and corn smut.

No. 26 (Vol. III, No. 11, 1890)—Ninth annual report. Meteorological summary. Index.

No. 27 (Vol. IV, No. 1, 1891)—Corn: Cultural, variety and fertilizer tests. *Out of print.*

No. 28 (Vol. IV, No. 2, 1891)—Miscellaneous experiments in the control of injurious insects *Out of print.*

No. 29 (Vol. IV, No. 3, 1891)—Fertilizers on wheat. *Out of print.*

No. 30 (Vol IV, No. 4, 1891)—Wheat: Cultural and variety tests and treatment for smut. *Out of print.*

No. 31 (Vol. IV, No. 5, 1891)—The wheat midge. *Out of print.*

No. 32 (Vol. IV, No. 6, 1891)—Experiments with small fruits. Diseases of the raspberry and blackberry. *Out of print.*

No. 33 (Vol. IV, No. 7, 1891)—The Hessian fly. *Out of print.*

No. 34 (Vol. IV, No. 8, 1891)—Forty years of wheat culture in Ohio. *Out of print.*

No. 35 (Vol. IV, No. 9, 1891)—Apple scab. The spraying of orchards. *Out of print.*

No. 36 (Vol. IV, No. 10, 1891)—Tenth annual report. Meteorological summary. Index. *Out of print.*

No. 37 (Vol. V, No. 1, 1892)—Oats: Cultural and variety tests.

No. 38 (Vol. V, No. 2, 1892)—Mangel wurzels and sugar beets.

No. 39 (Vol. V, No, 3, 1892)—Fertilizers on corn and oats.

No. 40 (Vol. V, No. 4, 1892)—Insects which burrow in the stem of wheat.

No. 41—Not published.

No. 42 (1892)—Wheat: Cultural and variety tests.

No. 43 (1892)—Greenhouses and greenhouse work. The food of the robin.

No. 44 (1892)—The rusts of Ohio. Wild lettuce. Scab of wheat.

No. 45 (1892)—Insects affecting the blackberry and raspberry.

No. 46 (1892)—Underground insect destroyers of the wheat plant.
No. 47 (1892)—Eleventh annual report. Meteorological summary. Index
No. 48 (1893)—Profit in spraying orchards and vineyards *Out of print.*
No. 49 (1893)—Field experiments with fertilizers.
No. 50 (1893)—Experiments in feeding for milk.
No. 51 (1893)—Miscellaneous entomological papers.
No. 52 (1893)—Twelfth annual report. Meteorological summary Index
No. 53 (1894)—Field experiments with commercial fertilizers.
No. 54 (1894)—Strawberries. *Out of print.*
No. 55 (1894)—The Russian Thistle in Ohio
No. 56 (1894)—The San Jose Scale.
No. 57 (1894)—Oats: Variety and cultural experiments.
No. 58 (1894)—Thirteenth annual report. Meteorological summary. Index
No. 59 (1895)—Noxious weeds along thoroughfares and their destruction.
No 60)1895)—Feeding for beef.
No. 61 (1895)—Sub-irrigation in the greenhouse
No. 62 (1895)—The grape-root worm.
No. 63 (1895)—Orchard spraying and notes on varieties of raspberries
No. 64 (1895)—The smut of oats.
No. 65 (1895)—Variety trials with potatoes.
No. 66 (1895)—Fourteenth annual report. Meteorological summary. Index.
No. 67 (1896)—Oats: Variety and cultural experiments; treatment for smut
No. 68 (1896)—Some destructive insects.
No. 69 (1896)—The chinch bug.
No. 70 (1896)—Forage crops.
No. 71 (1896)—The maintenance of fertility. Field experiments with fertilizers
No. 72 1896)—Peach Yellows, Black Knot and San Jose Scale.
No. 73 (1896)—Investigations of plant diseases in forcing house and garden.
No 74 (1896)—Fifteenth annual report. Meteorological summary. Index.
No. 75 (1897)—Beet sugar production.
No. 76 (1897)—Potatoes: Cutural notes and variety and fertilizer tests
No. 77 (1897)—The chinch bug and other destructive insects.
No. 78 (1897)—Corn: Cultural and variety tests. Corn smut.
No. 79 (1897)—Some diseases of orchard and garden fruits.
No. 80 (1897)—The maintenance of fertility. Field experiments with fertilizers
No. 81 (1897)—The San Jose scale in Ohio.
No. 82 (1897)—Wheat: Cultural and variety tests.
No. 83 (1897)—A first Ohio weed manual.
No. 84 (1897)—Sixteenth annual report. Meteorological summary. Index
No. 85 (1897)—Strawberries: Cultural notes and variety tests.
No. 86 (1897)—The story of the lives of a butterfly and a moth.
No. 87 (1897)—The Periodical Cicada, or so-called Seventeen-year Locust, in Ohio.
No. 88 (1897)—Co-operative experiments made by the Ohio Agricultural Students' Union in 1896.
No. 89 (1897)—Prevalent diseases of cucumbers, melons and tomatoes.
No. 90 (1898)—Sugar beet investigations in 1897.
No. 91 (1898)—The lung and stomach worms of sheep.
No. 92 (1898)—Preliminary report upon diseases of the peach. Experiments in spraying peach trees.
No. 93 (1898)—The home-mixing of fertilizers.
No. 94 (1898)—The maintenance of fertility. Field experiments with fertilizers in 1897
No. 95 (1898)—Seventeenth annual report. Meteorological summary. Index.
No. 96 (1899)—The Army Worm and Other Insects; Wheat and Grass Sawflies; the Corn or Boll Worm; the Painted Hickory Borer; the Raspberry Cane Borer; the Peach Scale.
No. 97 (1899)—Diseases of wheat and oats.
No. 98 (1899)—Small fruits: Cultural notes and comparison of varieties.
No. 99 (1899)—Sugar beet investigations in 1898.
No. 100 (1899)—A comparison of factory-mixed and home-mixed fertilizers
No. 101 (1899)—Experiments with oats.
No. 102 (1899)—Soil and seed treatment and spray calendar for insect pests and plant diseases.
No. 103 (1899)—The San José Scale in Ohio.
No. 104 (1899)—Further studies upon spraying trees and upon diseases of the peach
No. 105 (1899)—Further studies of cucumber, melon and tomato diseases.
No. 106 (1899)—I. The chinch bug. II. Experiments with insecticides.
No. 107 (1899)—The Hessian Fly.
No. 108 (1899)—Bovine Tuberculosis.
No. 109 (1899)—Eighteenth annual report Meteorological summary Index.

No. 110 (1899)—The maintenance of fertility.
No. 111 (1899)—Investigations of plant diseases
No. 112 (1899)—The Clover Root Borer.
No. 113 (1899)—Plums, comparison of varieties.
No. 114 (1899)—How insects are studied at the Ohio Agricultural Experiment Station
No. 115 (1900)—Sugar beets and sorghum: Investigations in 1899.
No. 116 (1900)—The grape-cane Gall-maker and its enemies.
No. 117 (1900)—Stomach worms in sheep.
No. 118 (1900)—Field experiments with wheat.
No. 119 (1900)—The Hessian Fly in 1899 and 1900.
No. 120 (1900)—Nineteenth annual report. Meteorological summary. Press bulletins Index
No. 121 (1900.—A condensed handbook of the diseases of cultivated plants in Ohio.
No. 122 (1900)—Onion Smut—Preliminary experiments.
No. 123 (1901)—I. Grape rots in Ohio. II. Experiments in the prevention of grape rot.
No. 124 (1901)—The maintenance of fertility: Field experiments with fertilizers on corn, oats and wheat in 1899 and 1900.
No. 125 (1901)—The maintenance of fertility: Field experiments on potatoes. 1894 to 1900
No. 126 (1901)—Sugar beet investigations in Ohio in 1900.
No. 127 (1901)—Miscellaneous chemical analyses.
No. 128 (1901)—Twentieth annual report. Meteorological summary. Press bulletins.

This Station has also published four bulletins in a "Technical Series," the first three numbers of which are devoted to entomological and botanical papers, the last to a list of the birds of Wayne county, Ohio.

Ohio Agricultural Experiment Station.

BULLETIN 128

INDEX SUPPLEMENT.

WOOSTER, OHIO, 1901.

GENERAL INDEX TO REPORTS AND BULLETINS, VOLUMES 1 TO 20, 1882 TO 1901.

NORWALK, O.
THE LANING COMPANY.
1902.

GENERAL INDEX

TO THE REPORTS AND BULLETINS OF THE OHIO AGRICULTURAL EXPERIMENT STATION, FROM ITS ORGANIZATION UNTIL JUNE 30, 1901.

(Not including the "Technical Series.")

EXPLANATION.

The first six annual reports of this Station, for the years 1882 to 1887, inclusive, contain the full record of its work for that period. Such bulletins as were published during these years (" First Series ") were intended for newspaper use only, and were afterwards incorporated in the annual reports. The " Second Series " of bulletins began with 1888. The first seven of these were incorporated in full in the seventh annual report. For 1889 and since the bulletins have been paged consecutively and have not been reprinted in the annual reports, but are attached to these reports as appendices, the annual reports being paged in Roman numerals. Consecutive numbering of bulletins began with No. 42, dated August, 1892.

Up to the end of the year 1896 the annual volumes cover calendar years, but after that year they cover the fiscal years ending June 30, this change being made at the request of the U. S. Department of Agriculture.

In the index which follows the figures in bold face type (**82**, **83**, **97-8**, **98-9**, etc.), refer to the reports for the years 1882, 1883, etc., and the Roman numerals refer to pages in annual reports subsequent to 1888.

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*Bulletins 76 and 77—page numbers are duplicated.

INDEX TO TECHNICAL NAMES.

Ohio Agricultural Experiment Station.

BULLETIN 129

WOOSTER, OHIO, AUGUST, 1901.

FIELD EXPERIMENTS WITH WHEAT.

I. COMPARISON OF VARIETIES

II. CULTURAL INVESTIGATIONS.

The Bulletins of this Station are sent free to all residents of the State who request them. All correspondence should be addressed to
EXPERIMENT STATION, WOOSTER, OHIO.

NORWALK, O.:
THE LANING COMPANY
1901

1 Ex. Sta. Bul. 129.

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The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 129. AUGUST, 1901.

FIELD EXPERIMENTS WITH WHEAT.

BY J. FREMONT HICKMAN.

That the work herein reported may be compared with similar work of previous years upon the same subject, it is treated under the following divisions:

I. Comparison of varieties; (a) at the Central Station; (b) at the Northeastern Substation.

II. Cultural investigations; (a) Thick and thin seeding; (b) Early and late seeding; (c) Deterioration of seed.

I. COMPARATIVE TESTS OF VARIETIES OF WHEAT.

Those who have received former bulletins on the subject of wheat tests at this Station are doubtless informed upon the conditions under which our comparative tests have been made. It may, however, be helpful to repeat that the land upon which these experiments are conducted from year to year is what is usually termed a clay soil. It is farmed in a five-year rotation without anything more than ordinary care. The first consideration in all such work is uniformity of conditions, which includes natural fertility, drainage, time of plowing, preparation of the seed bed, time of seeding, quantity of seed, harvesting, threshing, etc.

In the handling of so many varieties storing is impossible, and threshing as they are hauled from the field is a tedious process and requires diligent attention to many little details to keep each variety reasonably pure. After using all possible precautions it is found necessary almost every year to hand pick some varieties that the small admixture of other sorts may be reduced to the minimum. The question is so frequently asked whether wheats do not mix when sowed in close proximity that it seems necessary to repeat again that mixing under such conditions is next to impossible. Two varieties of wheat may be

grown in adjoining drill rows year after year, without admixture except as the heads of one may be harvested with the other, or by some such accidental mixing. Direct crossing, without careful and painstaking effort, seems quite out of the question, other than by sheer accident, which must be exceedingly rare. The mixing of varieties of wheat must be regarded as a matter of mechanical conditions only. When the sower fails to remove every grain from the drill, after drilling a given variety, not only a chance is given for a mixture the following year, but such a result is almost assured. When the Hessian fly causes straw-broken wheat, or a storm lodges the grain, plots in close proximity are almost certain to receive and support heads from adjoining plots. Before cutting the grain under such conditions it is absolutely necessary to separate by hand labor such intermingled straw and grain, placing the heads of wheat of each plot directly over the ground upon which they grew.

When cut with the binder, as they usually are, the sheaves of the first swath from each plot naturally are dropped upon the adjoining plot. Machine labor cannot be depended upon to put these sheaves upon the ground to which they belong, but hand labor cautiously guided must return each sheaf to its proper place before it is shocked. From the shock to the grain sack similar precautions must be taken, the details of which it is not necessary to give in this connection.

In these variety tests the section set apart for each year affords space for ninety plots. Usually only sixty of these are available for different sorts, for the reason that every third plot is sown to a standard variety of wheat (Penquite's Velvet Chaff). The several varieties under test are compared with the mean yield of the plots of Velvet Chaff between which they were grown. The difference between this mean and the yield of the sort under consideration indicates whether it has produced more or less than the sort used as a standard. It is by this method of calculation that the second column in Table I is obtained. The difference between the totals of increase and decrease through a series of years, divided by the number of years a particular variety has been grown, gives the average increase or decrease in the yield of that variety for the number of years it has been grown in the comparative test of varieties. This method of calculation gives the results shown in the third column of Table I.

The yield of grain, as given in the first column of Table I, was calculated from weights taken at the machine before the grain was screened. It is necessary in these comparative tests to take weights of all varieties before screening, for the reason that the varying sizes of grain in the different varieties, passing over the same screen, would give more favorable results to the larger than to the smaller grained varieties.

SIZE OF BERRY.

A very large berry does not necessarily indicate a good variety of wheat, either in quality or productiveness. It may be suggestive of large yields, but evidence is wanting to confirm such assumption. The Rudy is one of the largest grained varieties grown at the Station, but an examination of the third column of Table I shows that the average yield on the Station grounds has been below some eighteen other varieties in the nine-year comparative test.

Again we find, upon turning to the Annual Report of this Station for 1892 (page 90), that more than twenty varieties grown that year show higher gluten contents than the Rudy, as indicated by the percentages of protein.

Taking the Mealy as one of the smallest grained varieties grown at the Station, we find on referring to the third column in Table I that it has given a higher average yield in bushels than any other variety grown for nine consecutive years. Referring again to the report of 1892, we find that this variety is only about six-tenths of one per cent. below the Rudy in its protein content.

GLUTEN IN WHEAT.

Millers and bakers generally agree upon the statement that the higher the percentage of gluten in wheat the better it is for making a good article of bread. Mr. David Chidlow, of the "Chidlow Institute of Milling and Baking Technology" of Chicago, is authority for the further statement that the gluten of a given variety of wheat is only relatively stable, and that the variation in percentage of gluten may amount to as much as three, or possibly four, per cent. He believes further, that where a number of varieties are grown upon the same soil under uniform conditions the entire series would yield relatively the same percentages of gluten, however much these percentages might vary from the normal.

It is a well known fact that many, if not all, of our best millers, to make the highest grade and best quality of flour, secure spring wheats from the Northwest to mix with our winter wheats. It is claimed that the best grades of flour cannot be turned out from using our winter wheats alone. One reason given for this is that the spring wheats bear a much more uniform percentage of gluten than the winter varieties. Another reason, which to the writer seems equally as potent as the above, is the fact, as Mr. Chidlow said, that a greater number of loaves of bread of equal size can be made out of a barrel of spring wheat than out of a barrel of winter wheat flour. Speaking further upon variations in varieties and kinds of wheat Mr. Chidlow said:

"Spring wheat patent flours are much more easily made into bread than winter patents. As there is a difference among flours of the same class so there is a still wider difference in flours of different classes. Comparing hard winter, soft winter and spring wheat flours there is much variation in the time that these flours mature in the dough. This irregularity of maturity in the dough is one of the reasons that the winter wheat flour is more difficult to handle by the baker to get good, uniform bread. Flours of the very highest order are the most unstable in dough making. During fermentation flours have mixed with them yeast and water, which rapidly changes the quality of the gluten. The change varies with the kind and activity of fermentation, and these changes are much more apparent in the soft winter wheat flours. Taking a pound of winter wheat flour and making it into a loaf it would be much smaller in volume than if made from the same weight of spring wheat flour. In order to get a loaf of bread of a certain volume from soft winter wheat flour the baker must use nearly, or quite, 10 per cent. additional flour in the loaf as compared with flour from spring wheat." *

The above explanation throws some light upon the well known custom of mixing spring wheats from the Northwest with our winter wheats, in order that the better grades of flour may be produced.

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* From notes taken upon the lecture of David Chidlow before the Operative Millers' Convention at Milwaukee, Wis., June 18, 1901.

WHEAT: TABLE 1—COMPARATIVE YIELD OF VARIETIES IN 1901.

Variety.	Yield per acre in bushels. 1901.	Increase (+) decrease (—) bushels. 1901.	Increase (+) decrease (-) 9 years' average. Bushels.	Date of ripening 1901.	Color of grain.	Bearded or smooth.	Weight per measured bushel. Before screening. Pounds	Weight per measured bushel. After screening. Pounds
American Bronze	12.83	+0.17	+0.38	July 13	Red	Smooth	53.5	57.5
Bearded Monarch	17.91	+2.00	+0.18	" 10	Red	Bearded	56.5	59.2
Bearded Winter Fife	13.58	+0.17	....	" 9	White	Bearded	55.2	58.0
Buda Pesth	18.75	+3.76	....	" 10	Red	Bearded	58.0	58.2
Currell's Prolific	17.16	+2.29	+2.10	" 11	Red	Smooth	57.0	57.5
Dawson's Golden Chaff	14.91	+1.50	....	" 10	White	Smooth	53.7	56.7
Diamond Grit	13.33	+0.25	....	" 10	Red	Bearded	56.0	58.7
Deitz	20.16	+2.67	+0.07	" 10	Red	Bearded	58.2	60.2
Democrat	18.91	+4.21	+0.98	" 11	White	Bearded	56.5	59.5
Early Arcadian	9.66	—3.42	....	" 11	White	Smooth	52.7	55.0
Early Genesee Giant	11.83	—2.33	....	" 10	Red	Bearded	52.5	56.7
Early Red Clawson	15.50	+0.51	—0.85	" 10	Red	Smooth	54.7	57.5
Early Ripe	19.33	+4.50	+4.02	" 10	Red	Smooth	55.0	58.7
Early White Leader	13.00	—0.87	—0.97	" 12	White	Smooth	54.0	56.2
Egyptian	22.25	+6.38	+2.43	" 10	Red	Bearded	59.0	60.0
Economy	19.50	—0.24	....	" 9	Red	Smooth	58.0	60.0
Forty-Fold	13.33	—2.83	....	" 9	White	Smooth	51.0	57.5
Fulcaster	16.75	+1.88	—0.06	" 11	Red	Bearded	56.7	58.2
Fultz	14.08	—0.08	+0.13	" 9	Red	Smooth	56.7	59.2
Fultzo-Mediterranean	15.66	—3.62	....	" 10	Red	Smooth	55.2	58.5
Giant Square Head	16.50	—0.91	....	" 11	White	Bearded	45.2	56.5
Gold Coin	14.66	—1.50	....	" 9	White	Smooth	52.2	58.0
Gypsy	22.91	+7.08	+3.67	" 10	Red	Bearded	57.2	59.0
Harvest King	20.33	+4.67	....	" 9	Red	Smooth	56.0	59.7
Harvest Queen	23.75	+4.47	....	" 10	White	Smooth	58.2	59.0
Hickman	21.16	+3.83	—0.02	" 10	Red	Smooth	58.0	60.0
Hindostan	21.66	+3.12	—0.37	" 10	Red	Bearded	58.7	60.5
Improved Fulcaster	15.66	+0.67	....	" 10	Red	Bearded	55.0	58.5
Improved Poole	19.08	+1.75	....	" 9	Red	Smooth	56.5	59.2
International No. 6	15.33	+0.92	....	" 9	White	Smooth	49.0	56.2
Jones' Longberry No. 1	14.25	—1.66	....	" 11	White	Bearded	54.5	55.5
Jones' Square Head	12.50	—1.08	—2.58	" 11	White	Smooth	53.2	57.0
Jones' Winter Fife	12.58	—1.00	—1.91	" 11	Red	Smooth	48.0	56.5
Lebanon	17.00	—0.49	+0.35	" 10	Red	Bearded	57.7	59.7
Lehigh	20.41	+2.58	+0.28	" 10	Red	Bearded	58.5	60.2
Long Amber	13.50	+0.25	....	" 12	Red	Smooth	53.2	56.5
Martin's Amber	13.33	....	—0.74	" 11	White	Smooth	55.0	56.5
Mealy	16.91	+1.58	+4.18	" 10	Red	Smooth	52.5	56.2
Mediterranean	21.33	+3.50	+2.07	" 9	Red	Bearded	58.0	60.2
Missouri Blue Stem	16.16	+0.25	—0.89	" 11	Red	Bearded	56.7	58.0
Mortgage Lifter	24.58	+4.84	....	" 9	Red	Bearded	59.0	60.2
New Columbia	10.66	+4.04	....	" 9	Red	Smooth	54.5	55.7
New Longberry	16.05	+0.38	—0.92	" 12	Red	Bearded	55.2	57.7
New Monarch	18.08	+3.34	+2.07	" 9	Red	Smooth	57.0	57.5
New Soules	16.58	+1.25	....	" 10	White	Smooth	47.5	57.5
Nigger	20.16	+5.33	+2.95	" 9	Red	Bearded	58.5	59.7
Nixon	12.50	+0.91	....	" 10	Red	Smooth	55.7	59.5
Oatka Chief	17.41	+2.67	....	" 8	Red	Bearded	52.2	56.0
Perfection	18.91	+5.66	....	" 9	White	Smooth	57.5	59.7
Pool	20.16	+4.50	+3.76	" 9	Red	Smooth	57.2	59.5
Pride of Genesee	15.00	+1.13	....	" 12	Red	Bearded	52.7	58.5
Red Cross	13.50	—1.49	....	" 10	Red	Smooth	53.7	57.2
Red Russian	18.08	+3.92	+3.77	" 9	Red	Smooth	52.0	59.2
Red Wonder	12.25	+1.16	....	" 10	Red	Bearded	56.2	59.5
Royal Australian	15.83	+1.67	—1.27	" 12	White	Smooth	53.7	57.0
Rural New Yorker No. 6	12.33	—2.41	....	" 10	Red	Smooth	50.0	54.0
Rudy	20.66	+0.33	—0.09	" 9	Red	Bearded	58.0	59.2
Rochester Red	14.50	—1.41	....	" 10	Red	Smooth	55.0	57.2
Sibley's New Golden	20.16	+1.62	—0.41	" 10	Red	Bearded	57.0	59.5
Silver Chaff	14.58	+1.25	—0.33	" 11	White	Smooth	51.7	57.5
Smith's Rust Proof	14.66	+2.00	....	" 12	White	Smooth	56.0	58.2
Stanley	16.75	+1.34	....	" 11	White	Bearded	55.7	57.2
Turkish Red	10.33	—5.37	....	" 12	Red	Bearded	50.0	57.7
Valley	20.66	+4.79	+1.90	" 10	Red	Bearded	57.7	59.5
*Velvet Chaff	15.15	....	....	" 7	Red	Bearded	57.2	57.7
White Golden Cross	14.50	+0.09	....	" 9	White	Bearded	52.5	57.2
Yellow Gypsy	20.16	+4.33	—0.67	" 10	Red	Bearded	57.0	59.0

*The yield per acre for the Velvet Chaff is the average of 30 plots.

Turning to Table I we have the yields per acre of the 67 sorts grown in the comparative test of 1901 and the increased, or decreased yield of each sort from the mean of the duplicate plots of the standard between which they were grown. The third column in this table gives the average yield of each sort per acre above or below that of the mean yield of the series of standard plots between which it has been grown for the last nine years. This table further shows the date of ripening of the several sorts, color of grain, whether bearded or smooth, together with the weights per measured bushel, both before and after screening. Using as a basis for comparison the method given on a previous page, we find that in 1901 the Gypsy yielded more than seven bushels more than the Velvet Chaff; the Egyptian more than six bushels more and the Nigger and Perfection each more than five bushels more per acre. The following eight varieties yielded this year from four to nearly five bushels more per acre than the Velvet Chaff: Democrat, Yellow Gypsy, Harvest Queen, Poole, Early Ripe, Harvest King, Valley and Mortgage Lifter.

The following six varieties yielded from about three to nearly four bushels more per acre than the Velvet Chaff: Hindostan, New Monarch, Mediterranean, Buda Pesth, Hickman and Red Russian.

The following six varieties yielded from two, to two and two-thirds bushels more per acre than the Velvet Chaff: Bearded Monarch, Smith's Rust Proof, Currell's Prolific, Lehigh, Deitz, and Oatka Chief.

The following eleven varieties yielded from about one to nearly two bushels per acre more than the variety used as a standard: Pride of Genesee, Red Wonder, New Soules, Silver Chaff, Stanley, Dawson's Golden Chaff, Mealy, Sibley's New Golden, Royal Australian, Improved Poole and Fulcaster.

Twelve other sorts yielded small margins more than the Velvet Chaff but the differences in yield are, as a rule, quite small.

The following four varieties gave yields from about three and one half to nearly four and one-half bushels less per acre than the Velvet Chaff: Early Arcadian, Fultz, Mediterranean, New Columbia and Turkish Red; while the Early Genesee Giant, Rural New Yorker, No. 6 and Forty-fold yielded from two and one-third to almost three bushels less than the Velvet Chaff.

The following six varieties yielded from one to one and two-thirds bushels less per acre than the Velvet Chaff: Jones' Winter Fife, Jones' Square Head, Rochester Red, Red Cross, Gold Coin and Jones' Longberry No. 1.

Six other varieties yielded from about an equal amount to about one bushel less per acre than the variety used as a standard.

The variation in weight per measured bushel is quite marked, ranging from 45 to 59 pounds before screening. As indicated by these weights, nearly all of the varieties are shriveled somewhat in the berry, most of them very little, while a few are quite badly shrunken. Ordi-

narily, wheat growers expect the later maturing varieties to shrivel more than the earlier ones. Some exceptions were quite noticeable this year One of the earliest varieties to ripen was the most shrunken of any among the sixty-seven sorts.

Four varieties weighed less than fifty pounds to the bushel before being screened, namely, Jones' Winter Fife, Giant Square Head, International No. 6 and New Soules. The last three are all white wheats. Twenty-seven out of sixty-seven sorts test less than fifty-five pounds: fourteen of these are red wheats and thirteen white. Forty-seven of the entire list are red wheats and only twenty white varieties. This fact, in connection with observations made at the thresher, warrants the assertion that a relatively larger proportion of the varieties of white wheats were shrivelled than of the red wheats. The average dates on which these white and red wheats were ripe and ready for the binder are almost identical.

Table II gives the yield of each sort grown in comparative test on the Station grounds for the years 1900 and 1901. It also gives the average yield per acre of all varieties that have been grown nine years consecutively, together with the average yield per acre of other sorts for the number of years each has been grown.

In connection with the average yield of each sort for the number of years it has been grown, the average yield per acre is given of the Velvet Chaff plot which grew next to it during the same years. By making this direct comparison of the varieties with the standard sort the relative yields can be readily seen.

WHEAT: TABLE II.—COMPARING YIELDS OF EACH VARIETY WITH THOSE OF A STANDARD SORT THROUGH A SERIES OF YEARS.

Yield in bushels per acre.

Name of variety.	Year.									
	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	Nine years' average.
American Bronze	29.50	19.20	11.46	7.50	24.00	23.66	16.50	15.33	12.83	16.77
Velvet Chaff	20.87	17.00	8.54	7.50	22.33	28.25	17.16	11.33	13.00	16.22
Bearded Monarch	23.91	22.20	8.20	9.62	29.66	27.16	20.33	10.58	17.91	18.84
Velvet Chaff	25.00	17.20	10.76	11.50	22.66	26.33	20.66	9.91	16.00	17.73
Bearded Winter Fife						26.50	18.75	9.66	13.58	17.12
Velvet Chaff						26.00	19.50	11.75	13.41	17.66
Buda Pesth							17 56	5.83	18.75	14.04
Velvet Chaff							21.08	9.00	15.83	15.30
Currell's Prolific	30.25	16.20	10.54	11.12	37.83	34.33	24.16	10.50	17.16	21.34
Velvet Chaff	25.64	18.50	12.50	10.50	31.16	29.25	19.75	11.41	15.58	19.36
Dawson's Golden Chaff						25.16	21.83	14.83	14.91	19.05
Velvet Chaff						26.50	19.50	12.41	13.41	17.95
Diamond Grit						20.58	16.75	12.00	13.33	15.66
Velvet Chaff						24.00	10.41	12.00	12.75	17.29
Deitz	34.50	16.90	8.87	8.33	25.50	31.50	19.33	11.33	20.16	19.60
Velvet Chaff	30.91	13.00	10.91	9.20	25.16	32.25	18.50	12.41	18.33	18.96
Democrat	34.83	15.00	9 33	9.00	27.25	28.50	25.83	7.58	18.91	19.58
Velvet Chaff	30.91	13.00	10.91	9 20	25.16	32 25	19.50	9.58	16.00	18.50
Early Arcadian						19.58	16.83.	10.33	9.66	14.10
Velvet Chaff						26.00	20.41	11.75	13.41	17.89
Early Genesee Giant		19.60	12.25	6.25	19.41	24.75	19.58	10.33	11.83	15.50
Velvet Chaff		18.30	9.20	7.33	20.66	26.09	18.25	11.50	14.00	15.66
Early Red Clawson	23.33	14.00	8.37	7.96	25.33	25.08	15.83	8 08	15.50	15.94
Velvet Chaff	23.75	18.40	8.79	10.33	25.66	28.41	18.66	9.08	15.83	17.65
Early Ripe	31.15	19.70	10.00	14.00	28.50	29 66	26.41	18 66	19.33	21.93
Velvet Chaff	26.41	18.50	11.41	10.66	25.50	26.16	17.91	10.91	15.08	18.06
Early White Leader	20.16	18.80	13.12	6.00	21.83	24.08	15.91	12.33	13.00	16.13
Velvet Chaff	20.75	17.80	10.37	8.20	21.50	28.25	18.25	11.50	14.00	16.74
Egyptian	33.41	14.70	12.25	10.62	25.16	32.00	22.33	18.75	22.25	20.72
Velvet Chaff										
Economy									19.50	
Velvet Chaff									19.16	
Forty-Fold				8.91	32.83	29.91	24.16	9.25	13.33	19.73
Velvet Chaff				9 33	33.33	35.25	18.00	9.58	16.91	20.40
Fulcaster	27.00	14.50	9.41	9.16	30.58	29.33	21.75	10.16	16.75	18.73
Velvet Chaff	25.64	17.20	11.54	11.75	33.00	27.83	19 75	9.58	14.16	18.98
Fultz	21.91	24.10	12.71	7.21	33.83	33.16	23.05	9.66	14.08	19.96
Velvet Chaff	26.66	22 00	14.04	12.00	30 66	29.41	20.16	11.33	18.66	19 99
Fulzo-Mediterranean							28.16	7.50	15.66	17.10
Velvet Chaff							22.83	17.41	19 16	19 80
Giant Square Head						30.00	18.00	10.41	16.50	18.72
Velvet Chaff						29.25	17 50	13 25	17.91	19.48
Gold Coin			12.79	4.50	20.33	22.75	18.08	7.91	14.66	14.43
Velvet Chaff			12 37	7.83	22.16	24.00	21 58	10.00	15.41	16.12
Gypsy	27.50	18.50	14.62	12.08	28.75	30 25	25.58	14.16	22.91	21.59
Velvet Chaff	25.50	16.50	10.76	12.29	25.66	30.08	21.08	9.00	15.83	18.52
Harvest King						23.16	16.16	19 66	20.33	19.82
Velvet Chaff						24.16	16.75	14.83	16.75	18.12
Harvest Queen							23 66	11.91	23.75	19.77
Velvet Chaff							23.00	11 88	19.41	18.06

Table II.—Continued.

Name of variety.	Year.									
	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	Nine years' average.
Hickman	19.41	19.80	9.25	7.75	26.83	24.50	17.00	15.66	21.16	17.93
Velvet Chaff	22.25	17.30	9.37	10.29	25.66	28.41	17.75	13.25	17.91	18.02
Hindostan	30.66	8.80	8.08	7.50	30.66	28.25	15.50	12.08	21.66	18.13
Velvet Chaff	27.33	12.40	13.91	12.45	27.08	25.75	15.06	12.00	18.75	18.37
Improved Fulcaster	....	....	....	....	....	29.00	22.41	8.83	15.66	18.97
Velvet Chaff	....	....	....	....	....	27.91	19.58	9.58	14.16	17.78
Improved Poole	....	....	11.62	12.00	30.75	36.00	25.83	16.41	19.08	21.67
Velvet Chaff	....	....	10.91	10.12	25.33	30.16	17.50	14.83	16.75	17.94
International No. 6	....	....	....	10.33	34.00	27.66	23.66	8.16	15.33	19.85
Velvet Chaff	....	....	....	8.58	30.00	24.25	19.50	8.66	13.41	17.40
Jones' Longberry No. 1.	....	....	....	....	....	....	19.91	8.00	14.25	14.05
Velvet Chaff	....	....	....	....	....	....	19.75	8.91	15.83	14.83
Jones' Square Head	18.91	11.80	10.50	5.58	23.33	23.00	12.83	8.91	12.50	14.15
Velvet Chaff	20.75	16.90	8.54	7.50	22.23	29.25	17.16	11.33	13.00	16.29
Jones' Winter Fife	20.75	15.80	11.08	7.25	21.66	22.00	14.08	10.50	12.58	15.07
Velvet Chaff	25.50	18.40	10.62	10.91	25.16	29.25	17.75	10.33	14.16	18.00
Lebanon	33.83	14.20	8.50	9.33	22.50	33.66	21.66	9.91	17.00	18.95
Velvet Chaff	29.41	14.40	11.66	9.62	24.75	31.33	18.33	12.08	16.66	18.67
Lehigh	29.16	10.00	8.91	10.33	30.91	28.66	16.00	14.33	20.41	18.74
Velvet Chaff	31.33	15.60	13.45	12.00	28.66	24.50	15.66	12.00	18.75	19.16
Long Amber	....	....	10.46	6.20	18.91	20.50	14.16	9.58	13.50	13.33
Velvet Chaff	....	....	10.58	8.33	21.83	24.75	17.91	13.00	13.75	15.73
Martin's Amber	29.41	13.80	12.08	8.66	28.66	28.75	18.25	11.58	13.33	18.28
Velvet Chaff	26.41	17.80	11.54	11.75	33.00	27.83	18.25	11.33	14.33	19.14
Mealy	36.58	33.10	16.54	11.75	36.33	30.00	29.91	15.00	16.91	24.46
Velvet Chaff	29.16	21.60	13.66	10.25	31.66	32.83	20.50	10.83	14.66	20.57
Mediterranean	31.25	15.20	13.29	12.66	32.00	30.33	18.33	16.50	21.33	21.21
Velvet Chaff	31.33	15.60	13.45	12.00	28.66	24.50	15.66	13.83	16.91	19.10
Missouri Blue Stem	27.47	14.60	7.58	7.29	24.83	28.00	18.50	6.41	16.16	16.76
Velvet Chaff	25.00	18.50	10.76	11.50	25.50	26.16	20.66	9.91	16.00	18.22
Mortgage Lifter	....	....	....	....	....	....	....	14.66	24.58	19.62
Velvet Chaff	....	....	....	....	....	....	....	11.83	20.33	16.08
New Columbia	....	32.20	12.96	6.25	30.50	34.75	21.41	2.75	10.66	18.93
Velvet Chaff	....	21.60	11.41	10.96	32.00	31.58	19.16	8.66	13.41	18.59
New Longberry	25.75	10.00	10.25	10.00	29.41	33.00	21.33	9.25	16.08	18.34
Velvet Chaff	25.64	22.10	12.50	10.50	31.16	29.25	17.33	11.41	15.58	19.49
New Monarch	30.41	22.20	14.16	11.33	33.66	24.75	25.16	13.41	18.08	21.46
Velvet Chaff	24.08	22.10	13.45	10.16	32.25	29.41	20.83	9.66	15.83	19.69
New Soules	....	....	....	11.04	34.50	31.33	25.83	11.33	16.58	21.76
Velvet Chaff	....	....	....	11.16	31.33	32.83	20.50	9.58	16.00	20.23
Nigger	33.91	29.20	8.04	9.29	32.41	34.00	20.16	12.41	29.16	22.17
Velvet Chaff	29.75	20.40	9.96	9.20	29.58	31.08	16.83	12.08	14.58	19.27
Nixon	....	....	....	....	....	19.50	24.83	15.41	12.50	18.06
Velvet Chaff	....	....	....	....	....	24.16	19.75	12.41	13.41	17.43
Oatka Chief	....	....	....	....	....	....	....	10.83	17.41	14.12
Velvet Chaff	....	....	....	....	....	....	....	12.41	13.41	12.91
Perfection	....	....	11.58	8.33	27.00	25.16	23.66	13.50	18.91	18.31
Velvet Chaff	....	....	12.37	7.33	22.16	24.75	21.58	12.00	12.75	16.13
Poole	35.00	29.20	11.00	12.58	28.75	33.53	21.00	16.41	20.16	23.10
Velvet Chaff	27.25	19.30	10.91	10.12	25.33	30.16	16.83	12.08	14.58	18.51
Pride of Genesse	....	....	8.71	8.00	22.00	21.00	14.50	11.25	15.00	14.35
Velvet Chaff	....	....	9.20	7.33	20.66	26.08	17.91	13.00	13.75	15.41

TABLE II—Concluded.

Name of variety.	Year.									
	1891.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	Nine years' average.
Red Cross	....	....	....	....	....	23.90	19.16	7.66	13.50	15.83
Velvet Chaff	....	....	....	....	....	26.50	19.50	10.83	14.16	17.03
Red Russian	30.00	25.60	13.96	12.16	37.75	32.66	31.58	14.00	18.08	23.97
Velvet Chaff	26 66	22.00	13 96	11.16	31.83	32.33	20.16	10.83	14.66	20.34
Red Wonder	....	....	....	....	....	26.00	19.16	13.50	12.25	17.73
Velvet Chaff	....	....	....	....	....	24.16	16.75	12.41	13.41	16.68
Royal Australian	25.50	9.90	11.29	9.66	30.33	21.50	17.66	11.41	15.83	16.94
Velvet Chaff	25.50	16.50	10.76	12.29	27.83	25.75	18.25	11.33	14.33	18.06
Rural New Yorker No. 6	....	....	....	....	....	....	23.25	9.66	12.33	15.08
Velvet Chaff	....	....	....	....	....	....	20.33	11.33	13.66	15.10
Rudy	34.91	13.70	7.04	10.75	27.83	30.75	12.83	13.08	20.66	19.06
Velvet Chaff	27.25	15.40	11.37	8.41	26.33	33.16	14.83	11.83	20.33	18.76
Rochester Red	....	14.50	11.79	7.37	24.41	23.50	16.16	8.91	14.50	15.14
Velvet Chaff	....	16.30	11.41	10.33	22.66	26.33	18.66	9.08	15.83	16.32
Sibley's New Golden	31.60	11.50	9.50	10.25	29.50	27.33	21.33	14.08	20.16	19.49
Velvet Chaff	30.60	14.00	11.91	11.35	27.08	25.75	18.50	12.41	18.33	18.81
Silver Chaff	26.66	14.20	10.54	8.33	29.33	27.00	18.08	12.16	14.58	17.08
Velvet Chaff	26.41	17.80	12.04	10.16	31.50	31.91	19.33	12.83	12.33	19.31
Smith's Rust Proof	....	....	12.79	7.66	33.83	26.66	17.83	10.91	14.66	17.76
Velvet Chaff	....	....	12.37	10.16	31.50	31.91	19.33	12.33	12.83	18.56
Stanley	....	....	....	....	....	26.50	19.16	7.08	18.75	17.87
Velvet Chaff	....	....	....	....	....	29.25	18.00	9.58	16.91	18.43
Turkish Red	....	....	....	....	....	....	20.50	8.58	10.33	13.13
Velvet Chaff	....	....	....	....	....	....	17.33	9.66	15.83	14.27
Valley	33.33	13.40	11.75	8.75	22.50	35.33	20.83	15.08	20.66	20.18
Velvet Chaff	29 41	14.40	11.66	9.62	24.75	31.33	18.33	12.06	16.16	18.64
White Golden Cross	....	....	12.83	7.12	30.50	29.33	26.16	7.75	14.50	18.31
Velvet Chaff	....	....	11.41	10.96	32.00	35.25	19.16	10.00	15.41	19.17
Yellow Gypsy	20.83	18.20	7.96	6.00	25.00	24.66	21.83	8.58	29.16	17.08
Velvet Chaff	23.75	18.40	8.79	10.66	25.66	30.08	17.91	8.91	15.83	17.77

SPECIAL MENTION OF SOME OF THE NEWER SORTS OF WHEAT.

The Station has received an unusually large inquiry through the mails concerning Mealy wheat. Many are asking as to its comparative merit; others, who secured seed last year, are enthusiastic over the yields obtained in the season's crop, while quite a number complain of the smallness of the berry and the amount of shriveled grains. In previous publications special attention has been called to the small grain, which is a characteristic of the Mealy wheat. That point has been spoken of again on a previous page of this bulletin so that it does not seem necessary to discuss that feature further. There are two or three isolated instances in which the fly has been reported as having done as much injury to the Mealy as to other varieties in the same, or adjoining, fields. But in fully ninety per cent. of these reports, received from different sections of the state, the statement is made that much less damage has been done by the fly to the Mealy than to other varieties, even where grown in the same field and under like conditions as to preparation of seed bed, time of seeding, etc. This confirms the observations made at this Station during the years the fly has been injuring the wheat. Whether the fly really works less upon the Mealy than upon other varieties may be an open question. If, however, it does it is quite evident that the Mealy does not fall to the same extent that others do, or that it has superior recuperative abilities.

The shriveling of the grain is as yet the most serious charge to be considered. While a large proportion of those reporting as to its condition this season speak of shriveled grains but few of them indicate that the Mealy is worse in this respect than other varieties. Our information upon this point is as yet too limited to justify any conclusion, other than to suggest to the sower a few words of caution. The Mealy, though a small grained variety, apparently tillers more than the average wheat and from our experience and observation it is not best to recommend this wheat for low, rich or bottom lands; neither is it recommended for extremely fertile land of any kind. It will likely do well on any upland where it is not over stimulated. For further information upon this wheat see Bulletin 118 of this Station, page 221.

A variety of wheat known as Turkish Red was added to our list for comparative test in the fall of 1899. It is a rather small grained variety, but has a red and comparatively hard berry. We have grown three crops of this wheat without any evidence of superiority in productiveness. It is a bearded wheat, with a soft, weak straw. As shown in in Table III, its average yield for the past three seasons has fallen about one bushel below the average of the Velvet Chaff. The seed of Dawson's Golden Chaff came direct from Canada to this Station in the fall of 1897. It is reported from some sections as being comparatively free from the attacks of the Hessian fly. Observations upon this variety

where it was grown with other varieties at this Station do not justify the assertion that it was less injured by the fly than others, where all were under equal conditions and like surroundings. Dawson's Golden Chaff is a white, smooth wheat, and in the four years we have grown it has not demonstrated that it is a superior yielder in northern Ohio.

COMPARISON OF VARIETIES BY INCREASE OR DECREASE FROM THE YIELD OF A GIVEN STANDARD VARIETY.

Using the same basis of calculation in Table III as was used in Table I, we find among the several varieties grown but two, the Mealy and Early Ripe, which average more than four bushel per acre more than the Velvet Chaff; Red Russian and Poole stand third and fourth, with practically the same average excess, namely, three and three-fourth bushels more per acre than the standard variety. The Gypsy in the nine year average in this comparison falls but little below Red Russian and Poole.

Other varieties, averaging two bushels and more per acre more than Velvet Chaff, are Nigger and Egyptian; the former averaging almost three bushels and the latter about two and one-half bushels more, while the four following average practically two bushels more, viz: Currell's, Prolific, Mediterranean, New Monarch and Valley.

Those averaging more than a bushel less than the Velvet Chaff in this nine-year comparison are Jones' Square Head, with an average of 2.58 bushels; Jones' Winter Fife, 1.91 bushels; and Royal Australian, with 1.28 bushels less respectively. Early White Leader, New Longberry and Martin's Amber average from three-fourths to nearly a bushel less per acre than Velvet Chaff.

The last column in this table shows at a glance whether any given variety has given an average yield below or above the standard sort for the whole number of years the variety under consideration has been in the comparative test.

WHEAT: TABLE III—COMPARISON OF VARIETIES BY INCREASE OR DECREASE FROM THE YIELD OF A GIVEN STANDARD VARIETY.

Name of variety.	Average increase or decrease—Five year period or less.		Average increase or decrease—Four year period or less.					Average increase or decrease—Nine years.	
			1898	1899.	1900.	1901.	Average.		
	Yrs	Ave.						Yrs	
American Bronze	5	+1.17	−4.92	−1.38	+3.69	+0.17	−0.61	9	+0.38
Bearded Monarch	5	−0.14	+0.89	+0.33	−0.94	+2.00	+0.57	9	+0.18
Bearded Winter Fife	...	...	−0.13	−1.20	−2.09	+0.17	−0.81	4	−0.81
Buda Pesth	...	...	...	...	−3.37	+3.76	+0.20	2	+0.20
Currell's Prolific	5	+1.74	+4.20	+5.01	−0.30	+2.29	+2.80	9	+2.10
Dawson's Golden Chaff	...	...	−1.81	+3.02	+2.14	+1.50	+1.21	4	+1.21
Diamond Grit	...	...	−4.08	−4.05	+0.08	+0.25	−1.95	4	−1.95
Deitz	5	+0.05	−0.44	−0.89	−0.97	+2.67	+0.09	9	+0.07
Democrat	5	+0.29	−1.58	+5.95	−1.70	+4.21	+1.72	9	+0.93
Early Arcadian	...	...	−5.75	−3.35	−1.51	−3.42	−3.51	4	−3.51
Early Genesee Giant	4	−0.25	−2.05	−1.33	−1.12	−2.33	−1.71	8	−0.98
Early Red Clawson	5	−0.31	−2.63	−2.53	−1.42	+0.51	−1.52	9	−0.85
Early Ripe	5	+2.91	+2.19	+7.58	+7.36	+4.50	+5.41	9	+4.02
Early White Leader	5	−0.37	−3.44	−2.23	−0.33	−0.87	−1.72	9	−0.97
Egyptian	5	+1.62	−0.55	+5.50	+2.45	+6.38	+3.45	9	+2.43
Economy	...	...	...	...	−3.00	−0.24	−1.62	2	−1.62
Forty-Fold	2	−0.51	−3.95	+5.77	−0.47	−2.83	−0.37	6	−0.42
Fulcaster	5	−1.22	+2.19	+1.56	−0.03	+1.88	+1.40	9	−0.06
Fultz	5	−0.56	+2.87	+2.78	−1.51	−0.08	+0.99	9	+0.18
Fultzo-Mediterranean	...	...	...	...	−8.52	−3.62	−6.07	2	−6.07
Giant Square Head	...	...	+4.00	+0.83	−1.62	−0.91	+0.58	4	+0.58
Gold Coin	3	+1.35	−1.50	−3.11	−1.95	−1.50	−2.02	7	−0.57
Gypsy	5	+2.71	...	...	+5.19	+7.08	+6.14	9	+3.67
Harvest King	...	...	−1.78	−1.28	+5.74	+4.67	+1.84	4	+1.84
Harvest Queen	...	...	...	...	−2.72	+4.47	+0.88	2	+0.88
Hickman	4	+0.25	−4.19	−1.05	+1.89	+3.83	+0.12	9	+0.02
Hindostan	5	−1.64	+2.92	−1.11	−0.05	+3.12	+1.22	9	−0.37
Improved Fulcaster	...	...	+1.73	+2.68	−0.56	+0.67	+1.13	4	+1.13
Improved Poole	3	+2.41	+5.54	+8.55	+2.11	+1.75	+4.49	7	+3.59
International No. 6	2	+1.58	+3.33	+4.27	−0.94	+0.92	+1.90	6	+1.79
Jones' Longberry No. 1	...	...	...	...	−0.33	−1.66	−1.00	2	−1.00
Jones' Square Head	5	−1.73	−5.91	−4.53	−2.08	−1.08	−3.40	9	−2.58
Jones' Winter Fife	5	−1.12	−6.97	−3.47	−0.16	−1.00	−2.90	9	−1.91
Lebanon	5	+0.14	+2.03	+3.27	−2.28	−0.49	+0.68	9	+0.35
Lehigh	5	−1.17	+3.75	+0.33	+1.72	+2.58	+2.10	9	+0.28
Long Amber	3	−2.02	−4.69	−4.97	−3.08	+0.25	−3.12	7	−2.65
Martin's Amber	5	−1.15	−0.44	−0.36	−0.08	...	−0.22	9	−0.74
Mealy	5	+4.86	−2.41	+9.52	+4.58	+1.58	+3.32	9	+4.18
Mediterranean	5	+0.66	+5.92	+2.67	+3.28	+3.50	+3.84	9	+2.07
Missouri Blue Stem	5	−1.32	+1.79	−1.24	−2.25	+0.25	−0.36	9	−0.89
Mortgage Lifter	...	...	...	...	+1.83	+4.84	+3.34	2	+3.33
New Columbia	4	+1.20	+1.95	+2.14	−6.22	−4.04	−1.54	8	−0.17
New Longberry	5	−2.71	+3.70	+2.79	−1.57	+0.38	+1.33	9	−0.92
New Monarch	5	+2.17	−4.60	+5.83	+3.20	+3.34	+1.94	9	+2.07
New Soules	2	+1.63	−1.33	+5.66	+1.33	+1.25	+1.73	6	+1.69
Nigger	5	+2.84	+3.23	+3.09	+0.72	+5.33	+3.09	9	+2.95
Nixon	...	...	−5.34	−6.08	+3.00	+0.91	−1.88	4	+1.16
Oatka Chief	...	...	...	...	−0.08	+2.67	+1.30	2	+1.30
Perfection	3	+1.18	+0.66	+3.30	+1.17	+5.66	+2.70	7	+2.05
Poole	5	+3.87	+2.67	+3.95	+3.41	+4.50	+3.68	9	+3.76
Pride of Genesee	3	−0.50	−4.64	−3.52	−1.25	+1.13	−2.07	7	−1.40
Red Cross	...	...	−2.72	+1.04	−2.26	−1.49	−1.36	4	−1.36
Red Russian	5	+3.12	+0.17	+11.31	+3.00	+3.92	+4.60	9	+3.77
Red Wonder	...	...	+1.84	+1.41	+1.09	+1.16	+1.38	4	+1.38
Royal Australian	5	−1.51	−4.94	−0.59	−0.02	+1.67	−0.97	9	−1.27
Rural New Yorker No. 6	...	...	...	...	−2.11	−2.41	−2.26	2	−2.26
Rudy	5	+1.00	−1.41	−4.50	−0.25	+0.33	−1.46	9	−0.09
Rochester Red	4	−1.18	−3.52	−3.16	−0.45	−1.41	−2.14	8	−1.66
Sibley's New Golden	5	−0.56	−0.58	−3.78	+1.81	+1.62	−0.23	9	−0.41
Silver Chaff	5	−1.41	+3.55	−0.89	+0.16	+1.25	+1.02	9	−0.33
Smith's Rust Proof	...	...	...	...	−1.08	+2.00	+0.46	2	+0.41
Stanley	...	...	+0.50	+1.33	−3.73	+1.34	−0.14	4	−0.14
Turkish Red	...	...	...	...	−1.66	−5.37	−3.52	2	−3.52
Valley	5	+0.55	+3.39	+2.75	+3.39	+4.79	+3.58	9	+1.90
White Golden Cross	...	...	...	...	−1.80	+0.09	−0.86	2	−0.86
Yellow Gypsy	5	−1.75	−4.11	+2.86	−0.86	+4.83	+0.68	9	−0.67

COMPARISON OF WEIGHTS PER MEASURED BUSHEL FOR NINE CONSECUTIVE YEARS.

Table IV gives the weight per measured bushel of all sorts grown continuously for nine years in the comparative test, together with like weights for the sorts grown a less number of years which are still in the list. Of the thirty-four sorts in this list for the full nine years not one shows an average weight up to the standard of sixty pounds. Gypsy averages within one-tenth of a pound of the standard while eleven others fall less than one pound below. Nearly all those in the nine-year comparative test average above fifty-eight pounds. Two sorts, both white wheats, fall below fifty-seven pounds per bushel, namely: Jones' Square Head and Early White Leader. In making comparisons in this table it is fair to use only those sorts that have been grown an equal number of and during the same years. The low weight per bushel cannot be attributed to any one cause, but must be regarded as having been dependent upon varying conditions. In some seasons it has been caused by the Hessian fly, in others by rust and in still others by meteorological conditions at time of ripening. It is commonly believed, and observation bears out the belief, that low yields per acre, and low weights per bushel, frequently go hand in hand. Furthermore, the fact has been pretty clearly demonstrated, in our thick and thin seeding, that the lighter seeding gives a product weighing less per measured bushel than where the ground is seeded to its capacity to produce a maximum crop.

WHEAT: TABLE IV.—COMPARISON OF WEIGHTS PER MEASURED BUSHEL.

Name of variety.	First period five years or less.		Second period four years or less.					Nine years' average.	
	No. years.	Average	1898.	1899.	1900.	1901.	Average	No. years	Average
American Bronze	5	58.5	58.5	59.0	59.0	57.5	58.5	9	58.5
Bearded Monarch	5	59.5	58.5	60.0	58.7	59.2	59.1	9	59.3
Bearded Winter Fife			59.0	59.5	59.5	58.0	59.0		
Buda Pesth				58.5	56.2	58.2	57.6		
Currell's Prolific	5	58.6	60.0	60.2	59.2	57.5	59.2	9	58.9
Dawson's Golden Chaff			57.0	58.2	59.0	56.7	57.7		
Diamond Grit			60.0	60.2	59.7	58.7	59.7		
Deitz	5	59.2	60.0	58.0	58.2	60.2	59.1	9	59.2
Democrat	5	58.0	60.0	59.0	57.2	59.5	58.9	9	58.4
Early Arcadian			56.5	57.0	58.0	55.0	56.6		
Early Genesee Giant	4	56.9	58.5	58.7	57.7	56.7	57.9		
Early Red Clawson	5	57.2	58.0	58.5	58.5	57.5	58.1	9	57.6
Early Ripe	5	59.1	59.0	59.5	58.7	58.7	59.0	9	59.1
Early White Leader	5	56.7	55.5	57.0	58.0	56.2	56.7	9	56.7
Egyptian	5	58.8	61.0	57.2	60.0	60.0	59.6	9	59.1
Economy					59.5	60.0	59.8		
Forty-Fold	2	55.5	58.5	55.2	57.0	57.5	57.1		
Fulcaster	5	60.0	60.0	60.0	59.5	58.2	59.4	9	59.5
Fultz	5	58.7	60.0	60.0	59.7	59.2	59.7	9	59.2
Fultzo-Mediterranean				60.5	58.0	58.5	59.0		
Giant Square Head			59.5	55.5	56.0	56.5	56.9		
Gold Coin	3	55.7	59.0	59.0	56.0	58.0	58.0		
Gypsy	5	60.1	58.5	60.2	60.5	59.0	59.6	9	59.9
Harvest King			56.5	57.7	59.5	59.7	58.4		
Harvest Queen				57.5	57.0	59.0	57.8		
Hickman	5	59.8	59.5	60.0	60.0	60.0	59.9	9	59.8
Hindostan	5	58.8	61.0	58.0	59.0	60.5	59.6	9	59.2
Improved Fulcaster			61.0	61.0	59.5	58.5	60.0		
Improved Poole	3	57.4	61.0	57.5	60.0	59.2	59.4		
International No. 6	3	58.2	57.5	55.7	57.0	56.2	56.6		
Jones' Longberry No. 1				59.2	56.0	55.5	56.9		
Jones' Square Head	5	55.9	57.0	58.2	57.2	57.0	57.4	9	56.6
Jones' Winter Fife	5	57.2	58.0	58.2	59.2	56.5	58.0	9	57.5
Lebanon	5	58.7	61.0	58.2	58.0	59.7	59.2	9	58.9
Lehigh	5	58.7	60.2	57.5	58.5	60.2	59.1	9	58.9
Long Amber	3	56.4	59.0	58.2	59.0	56.5	58.2		
Martin's Amber	5	59.1	60.0	59.5	58.5	56.5	58.6	9	58.9
Mealy	5	57.5	58.0	58.0	58.2	56.2	57.6	9	57.6
Mediterranean	5	59.3	56.5	59.5	58.5	60.2	59.4	9	59.4
Missouri Blue Stem	5	58.8	59.5	60.0	58.2	58.0	58.9	9	58.9
Mortgage Lifter					59.0	60.2	59.6		
New Columbia	4	57.0	60.0	56.5	55.0	55.7	56.8		
New Longberry	5	58.4	59.5	59.5	58.0	57.7	58.7	9	58.5
New Monarch	5	58.6	58.0	59.7	59.2	57.5	58.6	9	58.6
New Soules	2	56.8	57.5	56.5	57.2	57.5	57.2		
Nigger	5	59.6	60.5	56.2	59.5	59.7	59.0	9	59.3
Nixon			60.0	61.0	61.2	59.5	60.4		
Oatka Chief					56.2	56.0	56.1		
Perfection	3	57.8	59.5	60.0	60.5	59.7	59.9		
Poole	5	58.5	61.0	57.5	58.2	59.5	59.1	9	58.8
Pride of Genesee	3	55.7	59.5	58.5	59.5	58.5	59.0		
Red Cross			57.5	58.5	58.0	57.2	57.8		
Red Russian	5	59.1	60.0	59.5	60.0	59.2	59.7	9	59.4
Red Wonder			60.0	61.5	62.0	59.5	60.5		
Royal Australian	5	57.4	58.5	58.0	59.2	57.0	58.2	9	57.8
Rural New Yorker No. 6				56.7	55.5	54.0	55.4		
Rudy	5	58.9	60.0	58.5	59.0	59.2	59.3	9	59.0
Rochester Red	4	57.7	58.0	58.0	59.0	57.2	58.1		
Sibley's New Golden	5	58.7	60.5	58.2	58.0	59.5	59.1	9	58.9
Silver Chaff	5	57.4	58.5	58.5	58.5	57.5	58.3	9	57.8
Smith's Rust Proof	3	56.0	58.0	59.0	59.0	58.2	58.6		
Stanley			60.0	55.5	55.0	57.2	56.9		
Turkish Red				59.7	58.5	57.7	58.6		
Valley	5	59.1	61.0	58.0	60.0	59.5	59.6	9	59.4
Velvet Chaff	5	59.2	59.5	59.6	59.2	58.7	59.3	9	59.2
White Golden Cross	3	58.0	59.5	56.5	57.2	57.2	57.6		
Yellow Gypsy	5	58.1	59.0	59.5	58.5	59.0	59.0	9	58.5

COMPARISON OF DATES OF RIPENING WITH RANGE FOR NINE YEARS.

Table V gives the dates of ripening for the several sorts in the comparative test through a series of years. It also shows in the last column the extreme dates, or range, in time of ripening. A number of sorts ripened this year from one to four and five days later than they had done in previous years, but the extreme range in time of maturing remains within a sixteen day limit, or about two weeks. 1899 marks a season in which all sorts ripened extremely early while the season of 1901 marks the other extreme.

The yield and quality of wheat in 1899 were both above the average, while the yield and quality of this season's crop may both be classed as inferior to the average.

The above facts only confirm a well grounded belief that early maturity usually gives a crop of better quality than where it matures later in the season.

WHEAT: TABLE V.—COMPARISON OF DATES OF RIPENING WITH RANGE, FOR NINE YEARS.

Varieties.	1893	1894	1895	1896.	1897	1898	1899	1900	1901	Range.
	July.	July.	July.	July.	July.	July	June.	July.	July.	June –July
American Bronze	13	11	8	4	8	4	28	2	13	28– 13
Bearded Monarch	11	11	6	2	8	1	26	2	10	26– 11
Bearded Winter Fife	....	....	....	....	....	2	27	2	9	27– 9
Buda Pesth	....	....	....	....	....	....	30	3	10	30– 10
Currell's Prolific	11	9	7	3	8	1	26	4	11	26– 11
Dawson's Golden Chaff	....	....	....	....	....	3	26	2	10	26– 10
Diamond Grit	....	....	....	....	....	4	28	5	10	28– 10
Deitz	10	10	10	3	8	1	28	2	10	28– 10
Democrat	10	10	10	3	8	4	28	4	11	28– 11
Early Arcadian	....	....	....	....	....	3	29	6	11	29– 11
Early Genesee Giant	....	11	8	3	10	4	26	6	10	26– 11
Early Red Clawson	10	12	8	2	8	1	28	4	10	28– 12
Early Ripe	10	11	8	1	8	1	26	4	10	26– 11
Early White Leader	12	11	8	4	10	4	26	6	12	26– 12
Egyptian	8	10	10	3	8	1	26	3	10	26– 10
Economy	....	....	....	....	....	....	....	3	9	July 3-9
Forty-Fold	....	....	....	8	8	2	28	3	9	June 28– 9
Fulcaster	10	12	9	June. 29	8	1	27	3	11	27– 12
Fultz	10	10	5	July. 1	8	1	27	4	9	27– 10
Fultzo-Mediterranean	....	....	....	....	....	....	26	4	10	26– 10
Giant Square Head	....	....	....	....	....	....	....	4	11	July 4-11
Gold Coin	....	....	....	July. 5	8	8	28	3	9	June 28– 9
Gypsy	11	8	8	2	8	2	26	3	10	26– 11
Harvest King	....	....	....	....	....	1	28	2	9	28– 9
Harvest Queen	....	....	....	....	....	....	28	4	10	28– 10
Hickman	11	10	8	1	8	1	26	2	10	26– 11
Hindostan	10	10	10	3	9	1	28	3	10	28– 10
Improved Fulcaster	....	....	....	....	....	2	28	3	10	28– 10
Improved Poole	....	....	12	1	8	1	26	2	9	26– 12
International No. 6	....	....	....	1	9	3	29	4	9	29– 9
Jones' Longberry No. 1	....	....	....	....	....	....	26	5	11	26– 11
Jones' Square Head	11	11	8	4	8	4	29	4	11	29– 11
Jones' Winter Fife	10	10	8	4	8	2	27	4	11	27– 11
Lebanon	10	10	10	3	9	1	28	2	10	28– 10
Lehigh	10	10	10	3	9	2	28	2	10	28– 10
Long Amber	....	....	6	4	8	4	29	2	12	29– 12
Martin's Amber	11	12	9	3	8	4	26	3	11	26– 12
Mealy	10	7	6	1	8	1	27	3	10	27– 10
Mediterranean	10	10	10	1	8	1	28	2	9	28– 10
Missouri Blue Stem	10	10	6	2	8	1	29	5	11	29– 11
Mortgage Lifter	....	....	....	....	....	....	....	4	9	July 4-9
New Columbia	....	7	6	1	8	2	23	4	9	June 23– 9
New Longberry	10	11	8	3	8	2	28	5	12	28– 12
New Monarch	11	10	10	2	8	1	27	4	9	27– 11
New Soules	....	....	....	2	8	2	28	5	10	28– 10
Nigger	8	7	12	1	8	1	26	3	9	26– 12
Nixon	....	....	....	....	....	1	26	2	10	26– 10
Oatka Chief	....	....	....	....	....	....	....	4	8	July 4–8
Perfection	....	....	5	1	8	2	26	2	9	26– 9
Poole	8	7	12	1	8	1	26	2	9	26– 12
Pride of Genesee	....	....	6	3	8	4	27	6	12	27– 12
Red Cross	....	....	....	....	....	1	26	4	10	26– 10
Red Russian	10	7	8	2	8	1	28	2	9	28– 10
Red Wonder	....	....	....	....	....	3	26	2	10	26– 10
Royal Australian	11	12	6	2	8	2	26	5	12	26– 12
Rural New Yorker No. 6	....	....	....	....	....	....	30	5	10	30– 10
Rudy	8	10	12	3	8	1	26	3	9	26– 12
Rochester Red	....	12	8	2	8	3	27	3	10	27– 12
Sibley's New Golden	10	10	8	3	9	1	28	3	10	28– 10
Silver Chaff	11	12	9	3	8	4	26	3	11	26– 12
Smith's Rust Proof	....	....	....	....	....	....	....	3	12	July 3-12
Stanley	....	....	....	....	....	6	28	4	11	28– 11
Turkish Red	....	....	....	....	....	....	30	3	12	30– 12
Valley	8	10	10	3	9	1	26	3	10	26– 10
Velvet Chaff	7	7	5	June. 27	6	1	24	1	7	27– 7
White Golden Cross	....	5	10	27	8	2	28	4	9	27– 10
Yellow Gypsy	9	11	8	July. 2	8	2	26	2	10	26– 11

(b) COMPARISON OF VARIETIES AT THE NORTHEASTERN SUBSTATION, AT STRONGSVILLE, CUYAHOGA COUNTY.

During the fall of 1897 and again in 1900 we found it possible to make comparative tests of a few varieties at Strongsville, Cuyahoga county, on what is described as a cold, heavy, white clay soil and is regarded as thin land, not as well adapted to wheat growing as the land at the central or home Station.

Table VI gives the data obtained from the results of these two tests, and shows that in the test completed in 1898 all the varieties tested gave smaller yields per acre than the Velvet Chaff, which was used as a standard of comparison the same as at the home station. In this first test it will be observed that the Poole and Lehigh gave yields almost identical with the variety used as the standard of comparison. In the second test, recently completed, nearly all varieties gave yields equal to, or better, than the Velvet Chaff. The Mealy, Currell's Prolific and Jones' Winter Fife are noticeable exceptions, all three falling from one and a half to about two bushels per acre below the Velvet Chaff. The first and last of these three fall about equally as far below the standard sort in the first test made in 1898.

From the column in Table VI, showing average increase, or decrease for the two years, we find that the Poole shows 1.40 bushels more per acre than the Velvet Chaff, while the Lehigh shows an average of 3.21 bushels more. The Jones Winter Fife and Rudy show an average yield of about two bushels less, while the Mealy has produced practically one and one-half bushels less per acre than the Velvet Chaff. Dawson's Golden Chaff, the only white wheat in the entire list, shows an average yield of about one and one-fourth bushels less per acre than the standard sort.

The Lehigh wheat, which makes the best showing for productiveness in the above table, shows also the highest weight per measured bushel, while the Mealy, which falls a bushel and a half below the standard in point of productiveness, shows a correspondingly low weight per bushel.

WHEAT: TABLE VI.—VARIETIES IN COMPARATIVE TEST AT STRONGSVILLE—1898 AND 1901.

Yield and increase in bushels per acre.

Name of variety.	Yield per acre, 1898.	Yield per acre, 1901.	Increase (+) decrease (—) 1898.	Increase (+) decrease (—) 1901.	Ave. increase or decrease	W't per bu. 1898. lbs.	W't per bu. 1901. lbs.	Ave. w't per bu. lbs.	Bearded or smooth.
American Bronze	......	8.75	......	+3.42	......	......	55.5	......	Smooth
Currell's Prolific	......	5.17	......	—1.83	......	......	58.5	......	"
Dawson's Golden Chaff	14.79	7.83	—2.35	—0.04	—1.20	57.2	56.5	56.9	"
Early Ripe	......	10.83	......	+5.50	......	......	56.5	......	"
Fultz	19.25	8.50	—0.37	+0.29	—0.04	59.5	58.0	58.8	"
Improved Poole	16.17	7.67	—1.55	+1.42	—0.07	58.5	56.7	57.6	"
Jones' Winter Fife	14.67	5.75	—2.73	—3.12	—3.43	56.5	56.0	56.3	"
Lehigh	17.58	13.50	—0.09	+6.50	+3.21	59.5	58.2	58.9	Bearded
Mealy	17.17	4.67	—1.40	—1.58	—1.49	56 7	54.7	55.7	Smooth
Nigger	......	10.00	......	+4.67	......	......	56.7	......	Bearded
Poole	18.00	12.67	—0.05	+2.84	+1.40	59.2	58.0	58.6	Smooth
Rudy	14.56	8.33	—5.28	+0.12	—2.58	59.0	58.2	58.6	Bearded
Valley	13.58	11.42	—3.45	+1.50	—0.43	57.5	58.5	58.0	Bearded
Velvet Chaff	......	......	......	......	......	......	......	......	......

II. CULTURAL INVESTIGATIONS.

Whatever is reported under this heading cannot be regarded as other than the continuation of work begun several years ago. The data submitted, like those upon previous pages of this bulletin, have been accumulated during the slow process of years. As they multiply and confirm other work of a like kind they grow that much more to be relied upon. Under the above heading will be considered the following topics: Thick and thin seeding; early and late seeding; deterioration of seed.

(a) THICK AND THIN SEEDING.

Since beginning this test in 1898 four different kinds of wheat have been used; one of these, the Valley, continuously. With the exception of the first year we have used two varieties. The several rates of seeding with the Valley have been duplicated each year with the second variety used that year. The Rudy was used three years, the Poole three and Fultz one. In addition to the duplication of the test here, the Velvet Chaff was used this year in a similar test conducted at the Northeastern Substation. The results, while varying in some particulars, agree in the main, and show by the accumulated average yields that the best results are obtained upon our clay and only moderately fertile lands by seeding from eight to ten pecks per acre rather than five or six. Not only better yields have been secured but a better quality of grain where the rate of seeding has been higher than most wheat growers are in the habit of drilling. Tables VII and VIII give the specific data for the several years that each variety has been used in this experiment, and show in no uncertain terms the advisability of using plenty, rather than a meager quantity of seed, if the best results are to be obtained. The higher rates of seeding are *not* recommended indiscriminately and for all soils, but for strong ground, such as first and second bottom or

other land especially rich in humus, a rate of seeding below eight pecks per acre may be sufficient, as has been indicated by similar experiments upon the better land at Columbus on the stronger first and second bottom lands of the Olentangy River.

WHEAT: TABLE VII.—THICK AND THIN SEEDING.

Yield in bushels per acre.

Year.	Pecks of seed per acre.							
	3	4	5	6	7	8	9	10
				Valley Wheat.				
1894............	5.00	6.20	8.30	6.80	8.20	10.85	10.50	12.50
1895............	6.20	6.87	7.29	6.78	8.04	9.49	....	....
1896............	6.49	7.95	8.83	7.33	8.00	8.66	....	....
1897............	18.58	17.79	18.03	20.33	19.41	20.25	20.08	18.58
1898............	12.91	12.33	15.41	17.04	17.75	21.59	21.54	22.79
1899............	23.16	19.62	21.29	23.33	22.76	23.24	26.16	24.33
1900............	7.83	7.13	7.20	8.08	10.58	10.33	9.56	11.41
1901............	21.12	20.54	21.83	21.96	21.91	22.75	21.00	20.91
Average......	12.66	12.30	13.52	13.96	14.58	15.90	....	....
				Rudy Wheat.				
1895............	2.33	3.33	3.74	5.12	5.50	5.12	....	5.25
1896............	6.33	6.49	5.03	7.25	8.83	10.16	10.33	10.66
1897............	16.95	22.24	21.87	22.53	24.24	26.37	24.41	29.33
Average......	8.53	10.69	10.21	11.63	12.86	13.88	....	15.08
				Poole Wheat.				
1898............	16.33	18.54	20.50	20.83	19.87	21.62	21.04	18.54
1899............	15.83	21.16	20.16	22.83	21.58	26.08	28.83	27.33
1900............	12.42	10.17	12.96	11.91	11.41	12.50	13.41	10.58
Average......	14.86	16.62	17.87	18.52	17.62	20.07	21.09	18.82
				Velvet Chaff—Strongsville.				
1901............	24.67	23.33	23.58	24.34	29.67	26.17	25.25	26.50
				Fultz Wheat.				
1901............	17.29	16.12	19.29	19.88	22.83	20.83	21.58	22.00
Comb'd Ave.	15.60	15.81	16.89	17.67	19.41	19.37	....	....

WHEAT: TABLE VIII.—THICK AND THIN SEEDING.

Weight per measured bushel.

Year.	Pecks of seed per acre.							
	3	4	5	6	7	8	9	10
				Valley Wheat.				
1894	57	58	58	58	58	59	59	59
1895	56	57	57	57	57	57	57	57
1896	59	60	61	60	61	61	61	60
1897	61	61	62	63	62	62	62	62
1898	54	54	54	56	55	57	59	59
1899	62	62	62	62	62	62	63	62
1900	59	59	59	59	60	....	60	60
1901	61	60	61	61	62	61	60	61
Average	59	59	59	60	60	....	60	60
				Rudy Wheat.				
1895	56	55	57	57	56	57	58	58
1896	53	53	54	55	55	55	56	56
1897	62	62	62	62	62	63	62	63
Average	57	57	58	58	58	58	59	59
				Poole Wheat.				
1898	57	57	58	58	57	57	58	58
1899	61	61	61	61	61	61	61	62
1900	59	59	59	59	58	59	58	59
Average	59	59	59	59	59	59	59	60
				Fultz Wheat.				
1901	60	59	59	59	60	60	60	60
				Velvet Chaff—Strongsville.				
1901	60	59	60	60	61	61	61	62
Combined Average	59	59	59	59	60	...	60	60

Table VIII, giving weights of measured bushel for the different rates of seeding from 1894 to 1901, inclusive, and including five distinct varieties of wheat, give specific evidence showing that the larger application of seed has given grain of a better quality than where it was sown extremely, or moderately light.

In the experiment of 1901 like results are shown at Wooster and Strongsville. Both confirm similar work of previous years at this Station.

(b) EARLY AND LATE SEEDING.

The Station has continued this experiment over fourteen years. Many of these years avoiding the Hessian fly was not a point to be investigated, for its depredation was not in evidence when the crop was growing nor when it was harvested. In the greater part of the years, when early and later seeding has been under consideration, the object sought after has been whether the earlier or later seeding was best from the standpoint of production, without regard to pests and foes. In all the experiments conducted along this line (with the single exception of 1895) since the work was transferred to Wooster, escaping the attack by the Hessian fly has been one of the points first in importance.

Table IX shows the yields per acre from different dates of seeding for nine years at Columbus, for four years at Wooster and for one year at Strongsville. An occasional year shows higher yields from seeding before the middle of September, but some of the highest yields have been secured from seeding after the first of October, both at Columbus and Wooster. The single experiment, concluded in 1901 at Strongsville, shows the highest yield from seeding between September 27 and October 1. The highest average yields in the work at this Station during the last three years are from sowings made during the first week in October.

While the data furnished in Table IX bring out some good, practical facts it does not seem to the writer that it would be a judicious practice for farmers generally to postpone their seeding so late in the season as to jeopardize the chances for a good, strong fall growth. The very early seeding is unquestionably a mistake, but it should not be offset by the other extreme.

WHEAT: TABLE IX.—EARLY AND LATE SEEDING OF WHEAT.

Date of seeding.	Year and yield per acre.														
	Columbus.										Wooster.				Strongsville.
	1879	1880	1883		1884	1886	1887	1888	1889	1890	1895	1899	1900	1901	1901
Aug. 22-25	.....	.....	24.1	.....	35.8	.....	31.7	12.8	.....	16.8	.....	.....	.....	.....	.....
Aug. 29—Sept. 1	.....	.....	.....	4.00	51.8	41.2	31.6	11.2	.....	16.8	.....	18.0	.....	9.8	21.9
Sept. 6-10	33.2	32 5	34.9	.....	55.6	32.3	28.3	12.1	34.9	19.1	8.5	18.3	.....	5.5	20.3
Sept. 13-17	30.3	33.0	.....	42.4	57.2	35.0	31.3	26.6	26.9	20.2	7.6	25.5	.....	5.7	17.7
Sept. 20-24	36.4	33.5	34.2	44.7	53.2	38.6	27.8	26.6	27.4	20.9	8.1	23.5	13.7	2.0	22.0
Sept. 27—Oct. 1	32.7	29.5	.....	47.1	54.6	42.1	26.1	26.1	42.4	22.5	5.0	22.8	16.7	14.0	24.7
Oct. 4-8	26.2	26.2	34.7	.....	56.9	36 5	32.7	28.2	47.3	26.5	5.7	21.5	15.7	19.5	22.2
Oct. 11-15	.....	.....	.....	38.0	44.4	38.0	30.6	33.0	33.8	22.6	5.7	19.3	10.4	19·8	22.9
Oct. 18-20	.....	.....	.....	.....	43.6	29.9	20.9	20.8	.....	23.0	5.0	11.2	8.0	11.7	.....
Oct. 25-27	.....	.....	.....	.....	35.6	.....	18.9	27.7	.....	.....	2.3	.....	.....	11.7	.....
Nov. 1	.....	.....	.....	.....	.....	.....	7.4	22.9	42.0	25.0	.....	.....	.....	.....	.....

(c) DETERIORATION OF SEED.

Theoretically, and on the principle that "like begets like," large grains of wheat should give higher yields per acre than smaller ones. With such faith and belief the writer started an experiment in 1891 to demonstrate that proposition. With the exception of a single year (1892) this experiment has been continued. Three grades of seed have been taken from each of three varieties; selected seed, second grade and unscreened seed. The selected seed consisted of the largest grains; the second grade, the best of the wheat that passed through in screening out the first grade and the unscreened the entire lot as it came from the thresher.

Naturally it was expected that from the first quality better wheat each succeeding year would be the result, and from the better quality greater yields. From the second grade and unscreened seed were expected inferior yields and an inferior berry. Table X gives the yields per acre of each grade and the average yield of the several kinds for a series of nine consecutive years, together with the quality of wheat produced from each as indicated by the weight per measured bushel.

The average results as shown do not furnish data to demonstrate the theory usually accepted. The only conclusion to be drawn from the above is that the quality of the seed does not influence materially the quantity and quality of the crop, or else the variation in the quality of the seed has not been sufficiently marked.

EXPLANATION.

The complete manuscript for this bulletin was delivered for printing August 23. The first installment of the printed bulletin was received at the Experiment Station November 4.

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Director.